INSTRUCTION MANUAL

B+K PRECISION 1650

Tri-Output Laboratory

Power Supply

B+K PRECISION DYNASCAN CORPORATION

WARNING

Normal use of test equipment exposes you to a certain amount of danger from electrical shock because testing must often be performed where exposed voltage is present. An electrical shock causing 10 milliamps of current to pass through the heart will stop most human heartbeats. Higher voltages pose an even greater threat because such voltage can more easily produce a lethal current. However, voltage as low as 35 volts DC or AC RMS should be considered dangerous and hazardous since it can produce a lethal current under certain conditions. Your normal work habits should include all accepted practices that will prevent contact with exposed high voltage, and that will steer current away from your heart in case of accidental contact with a high voltage. You will significantly reduce the risk factor if you know and observe the following safety precautions:

1. Don't expose high voltage needlessly. Remove housings and covers only when necessary. Turn off equipment while making test connections in high-voltage circuits. Discharge high-voltage capacitors after removing power.

2. Use an insulated floor material or a large, insulated floor mat to stand on, and an insulated work surface on which to place equipment; and make certain such surfaces are not damp or wet. Where insulated floor surface is not available, wear heavy gloves.

3. Use the time-proven "one hand in the pocket" technique while handling an instrument probe. Be particularly careful to avoid contacting a nearby metal object that could provide a good ground return path.

4. Always use an isolation transformer to power transformerless "hot chassis" equipment, where one side of the AC power line is connected directly to the chassis. This includes most recent television sets and audio equipment. Without an isolation transformer, the chassis of such equipment may be floating at line voltage (120 VAC, 60 Hz in USA), depending upon which way the 2-wire AC power plug is inserted. Not only does this present a dangerous shock hazard if the chassis is touched, but damage to test instruments or the equipment under test may result from connecting the ground lead to some test instruments to a "hot" chassis. The ground lead of most oscilloscopes and most other test instruments with 3-wire power plugs is at earth ground. The B & K-PRECISION Model TR-110 Isolation Transformer is suitable for most applications.

5. On test instruments or any equipment with a 3-wire AC power plug, use only a 3-wire outlet. This is a safety feature to keep the housing or other exposed elements at earth ground.

6. If possible, familiarize yourself with the equipment being tested and the location of its high voltage points. However, remember that high voltage may appear at unexpected points in defective equipment.

7. Also remember that AC line voltage is present on some power input circuit points such as on-off switches, fuses, power transformers, etc., even when the equipment is turned off.

8. Never work alone. Someone should be nearby to render aid if necessary. Training on CPR (cardio-pulmonary resuscitation) first aid is highly recommended.

INSTRUCTION MANUAL

FOR

B & K-PRECISION

MODEL 1650

TRI-OUTPUT LABORATORY POWER SUPPLY

B+K PRECISION DYNASCAN CORPORATION

6460 West Cortland Street

Chicago, Illinois 60635

TABLE OF CONTENTS

Page

INTRODUCTION 3

FEATURES 4

SPECIFICATIONS 5

OPERATING CONTROLS 6

OPERATING INSTRUCTIONS
- Safety Precautions 7
- Ventilation Considerations 7
- Use of 5-Volt Supply 9
- Independent Use of "A" Supply 10
- Independent Use of "B" Supply 12
- Tri-Output (Independent Mode) 13
- Tracking Operation 13
- Connecting Outputs in Series 15
- Connecting Outputs in Parallel 18

CIRCUIT DESCRIPTION
- 5-Volt Supply 19
- 5-Volt Protective Circuits 19
- "A" Supply 19
- "B" Supply 21
- Tracking Circuits 21
- Metering 22

MAINTENANCE AND CALIBRATION
- Removal of Top Cover 24
- Line Voltage Conversion (Export Models) 25
- Fuse Replacement 25
- Basic Troubleshooting Check List 25
- Calibration Adjustments 27

WARRANTY SERVICE INSTRUCTIONS 28

LIMITED ONE YEAR WARRANTY 28

INTRODUCTION

The **B & K-PRECISION** Model 1650 Tri-Output Laboratory Power Supply was designed for solid state applications where both digital and analog circuits are encountered. In one package, this unit combines a separate 5-volt DC supply and two continuously variable 0-25 volt DC supplies. The 5-volt supply is rated at 5 amps, which is adequate to handle extensive digital logic circuitry. The A and B, 0-25 volt, 0.5 amp variable supplies can be operated independently, or in a tracking mode. In the tracking mode, the B supply can be set to operate at any desired percentage of the A supply voltage from 0 to 100%. Then, the A control will simultaneously adjust both output voltages. For example, when the tracking is set at 100% and the A supply is set to 10 volts, the B supply will also be at 10 volts. If the A supply setting is changed to 12 volts, the B supply will also change to 12 volts. If the tracking percentage is set to 50% and the A supply is set to 10 volts, the B supply will operate at 5 volts. If the A supply is changed to 12 volts, the B supply will change to 6 volts.

All three outputs are completely isolated, even in the tracking mode. This offers full versatility of connections. The supplies may be operated independently, connected in series, connected back-to-back, or connected in parallel if suitable current balancing resistors are used. Laboratory quality is clearly evident in the 1650's specifications, including excellent regulation and tracking accuracy, low ripple content, and current-limiting overload protection.

The features and versatility of the unit, especially the tri-output and tracking abilities, make it an ideal general purpose power supply for engineering lab applications. It can serve as a single or multi-voltage power source, including the bias supply, for breadboard and prototype circuits and equipment. It can provide single or simultaneously varying voltages for circuit evaluation. It can provide tracking + and - voltages for evaluating differential amplifiers. It may be used as a battery eliminator, or to power individual circuit boards or cards while removed from the system. Its output can be evaluated while powering a breadboard or prototype circuit to determine the circuit's power supply requirements. Its laboratory quality specifications will meet most engineering laboratory requirements.

The same features that make the Model 1650 a good choice for an engineering lab also make it a good choice for most other solid state electronic applications. Yet, its low cost also makes it very practical for service shops; industrial production testing of components, assemblies, and complete equipments; for school laboratories, and home use by electronic hobbyists.

FEATURES

TRI-OUTPUT	Operates as three separate power supplies. Each has floating output and is completely isolated from the other two.
ONE 5VDC FIXED SUPPLY	Husky 0-to-5 amp fixed voltage supply operates at 5 volts DC, which is the voltage required for most digital logic circuitry. Adequate capacity for powering extensive circuitry.
TWO 0-25 VDC VARIABLE SUPPLIES	Two identical, continuously variable 0-to-25 volt supplies can be operated independently. Each supply has a 0-to-0.5 amp capacity.
UNIQUE TRACKING FEATURE	The two 0-25 volt supplies can be operated so that the B supply tracks the A supply at any selected ratio from 0 to 100%. For example: with tracking ratio set at 50%, B supply output will be 5 volts when A supply is set to 10 volts. B output will increase to 7.5 volts when A is set to 15 volts. Opto-isolator design allows complete isolation of the two supplies while tracking. Outputs can also be strapped for two positive voltages with a common negative, two negative voltages with a common positive, one positive and one negative voltage, in series for higher voltage output, or in parallel for higher current output (suitable current balancing resistors are required).
EXCELLENT TRACKING ACCURACY	B supply tracks A supply within ±1% in the most commonly used 2-to-22 volt range.
CURRENT LIMITING PROTECTION	All three supplies feature current limiting protection to prevent excessive output current if output is short-circuited or overloaded. Foldback current limiting method reduces output current proportional to degree of overload. 5-volt supply limits at approximately 2.5 amps, 0-25 volt supplies slightly above 0.5 amp when short-circuited.
OVERVOLTAGE PROTECTION	5-volt supply protects circuit being powered from overvoltage in case of power supply fault or accidental application of external voltage.
REVERSE POLARITY PROTECTION	All three supplies have reverse polarity protection that prevents damage to power supply if external voltage of reverse polarity is applied to supply's output terminals.
PROTECTION FOR CIRCUIT BEING POWERED	Under majority of normal operating conditions, design of power supply provides protection from overvoltage to circuit being powered by B supply if inadvertently or accidentally switched from tracking to independent mode. Direction of adjustment for increasing tracking ratio (ccw) is opposite that for increasing output voltage in independent mode (cw). If mode is changed to independent when set for 100% tracking ratio (fully ccw), B supply output will go to 0 volts instead of 25 volts.
METERING	Built-in meter can be switched to monitor output voltage or current of each supply. 0-5V and 0-5A scales for 5-volt supply, 0-25V and 0-0.5A scales for variable supplies.
ILLUMINATED METER	Also serves as pilot lamp for positive indication that unit is on.
BINDING POST	Heavy-duty, 5-way, color-coded binding posts for the output of each supply and earth ground.
EARTH GROUND	Case of power supply and green binding post both are connected to earth ground through the third wire of the AC power cord.

SPECIFICATIONS

INPUT POWER REQUIREMENTS	105-125 VAC, 60 Hz, 160 watts with all three outputs at maximum rated load. 105-125/210-250 VAC, 50/60 Hz export model available.
OUTPUTS	
5-Volt Supply	5 volts DC, -0, +2%.
A Supply	0-to-25 volts DC.
B Supply	0-to-25 volts DC.
REGULATION	
Load	±0.1% (±25mV) variation from 0-to-0.5A load on 25-volt supplies. ±3% (150mV) variation from 0-to-5.0A load on 5-volt supply.
Line	Less than 0.2% (50mV) variation for a line voltage change of 20 volts on 25-volt supplies (independent mode). Less than 0.4% (20mV) variation for a line voltage change of 20 volts on 5-volt supply.
RIPPLE & NOISE	
25-Volt Supplies	Less than 5mV RMS.
5-Volt Supply	Less than 10mV RMS.
PROTECTION	
Current Limiting	Limiting for each 0-25 volt supply fixed slightly above rated current for short circuit protection. The 5-volt supply has automatic foldback to approximately 2.5 amps short-circuited.
Overvoltage Protection	5-volt supply output protected at 7 volts.
ISOLATION	
Isolation Voltage Rating	Each supply may be floated independently. Maximum voltage difference between any of the three supplies is 250 volts (DC + AC peak).

GENERAL	
Series Operation	All three supplies may be connected in series.
Parallel Operation	25-volt supplies may be connected in parallel by adding suitable current equalizing resistors.
Meter Accuracy	
Voltage	± 5% of full scale.
Current	± 8% of full scale.
Meter Ranges	
Voltage	0-25 volts and 0-5 volts.
Current	0-0.5 amp and 0-5 amps.
Tracking	B supply tracks A supply at selected ratio which is continuously variable from 0-to-100%. Tracking operates whether supplies are connected in series, back-to-back, or completely isolated.
Tracking Error	±1% of rated voltage (±250mV) when both supplies are operated in the range of 2-to-22 volts. Tracking is obtained outside these limits with increased error.
Operating Temperature	
Full Load	+15 to +27°C. All three supplies will deliver full rated current.
Partial Load	+28 to +37°C. Maximum current is derated .015 A per degree C above 27° C for A and B supplies, 0.1 A per degree C above 27° C for 5-volt supply.
Size (HWD)	9.8 x 35.9 x 22.5 cm (3-7/8 x 14-1/8 x 8-7/8").
Weight	9.9 kg (22 lbs.)
CSA Listed	Yes.

OPERATING CONTROLS
(See Fig. 1)

1. **POWER ON-OFF Switch.**

2. **Meter.** Reads voltage or current of whichever supply has been selected by the METERING switch. Pilot lamp illuminates meter when unit is ON.

3. **METERING Switch.** Connects meter to measure output voltage or current from A supply, B supply, or 5-volt supply. Full scale equals 25 volts and 0.5 amp for A and B supplies, 5 volts and 5 amps for 5-volt supply.

4. **A VOLTS Control.** Adjusts output voltage of A supply from 0-to-25 volts when mode switch is in INDEPENDENT position. Adjusts output voltage of both A and B supplies when mode switch is in B TRACKS A position. Clockwise rotation increases voltage.

5. **A Supply Output Terminals.** Red terminal is +, black terminal is −, output is floating.

6. **Mode Switch.** Selects B TRACKS A or INDEPENDENT mode of operation.

7. **B VOLTS/TRACKING Control.** Adjusts output voltage of B supply from 0-to-25 volts when mode switch is in INDEPENDENT position; *clockwise* rotation increases voltage. Adjusts output voltage of B supply from 0-to-100% of A supply voltage when mode switch is in B TRACKS A position; *counterclockwise* rotation increases percentage.

8. **B Supply Output Terminals.** Red terminal is +, black terminal is −, output is floating in both INDEPENDENT and B TRACKS A modes.

9. **5 VOLTS, 5A MAX Terminals.** Output terminals for 5-volt supply. Red terminal is +, black terminal is −, output is floating.

10. ⏚ **Terminal (Green).** Earth ground.

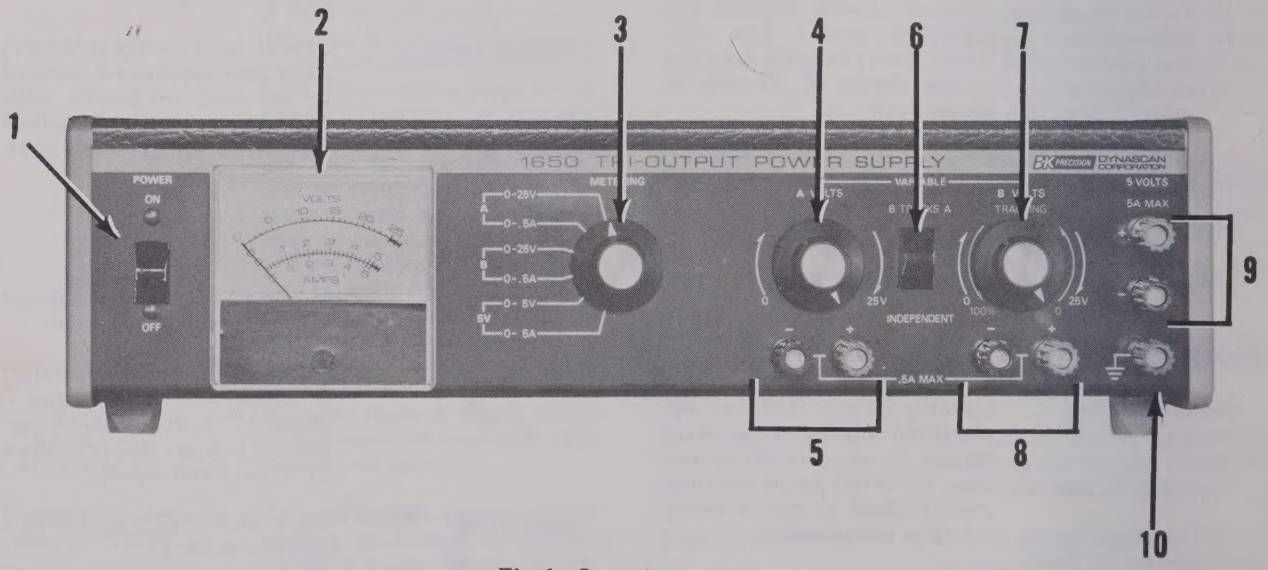


Fig. 1. Operating controls.

OPERATING INSTRUCTIONS

SAFETY PRECAUTIONS

Use only a polarized 3-wire AC outlet. This assures that the power supply chassis, case, and ground terminal are connected to a good earth ground and reduces danger from electrical shock. If a 2-wire to 3-wire adapter must be used, be sure the ground wire of the adapter is attached to a good earth ground.

There is little danger of electrical shock from the power supply outputs unless the 25-volt supplies are connected back-to-back or in series and operated at maximum voltage, or a power supply output is floated to a high voltage from the equipment to which it is connected. Some equipment being powered may contain high voltage and present a shock hazard. Observe caution.

All three supplies are isolated and any supply may be floated to a DC level from another power supply or the equipment under test. In fact, all three supplies may be simultaneously floated to separate DC levels if desired. Use extra caution when supplies are floated. The isolation rating of the 1650 allows difference voltage between supplies as high as 250 volts, which could produce fatal electric shock if contacted. Turn off the power supply *and the equipment under test* when making connections.

The power supply should always be turned off with the POWER ON-OFF switch. The switch contains a shorting section to instantaneously kill the B supply. When the B supply is lightly loaded, and the power plug is pulled or an external switch is used instead of using the POWER ON-OFF switch, the B supply output voltage may rise 2 to 3 volts as power is removed. The voltage rise could overvoltage some circuits being powered.

VENTILATION CONSIDERATIONS

The power supply's heat is radiated by the heat sink on the rear of the unit and by convection cooling through the ventilation holes in the top and bottom of the housing. For most effective dissipation of the heat, leave a few inches of unobstructed space around the unit. Never place an object directly on top of the power supply, such as another piece of test equipment, a diagram, or an instruction manual, as this will obstruct the ventilation holes that allow the heated air to escape from the chassis. The feet on the bottom of the unit give adequate clearance for cool air to be drawn into the chassis, but do not place material under the power supply or support it in a manner that will reduce this clearance.

The 1650 power supply is intended for use at normal room temperature and will provide full rated current from +15 to +27°C (59 to 81°F). Above 27°C the maximum output current is derated by 0.1 amp per degree C for the 5-volt supply and .015 amp per degree C for the A and B supplies. Maximum operating temperature is 37°C (99°F). If the unit is operated in excessive ambient temperature, or the ventilation is impeded, thus allowing heat to build up within the unit, maximum output current is reduced and component failure can occur. (See Note 2 on page 11.)

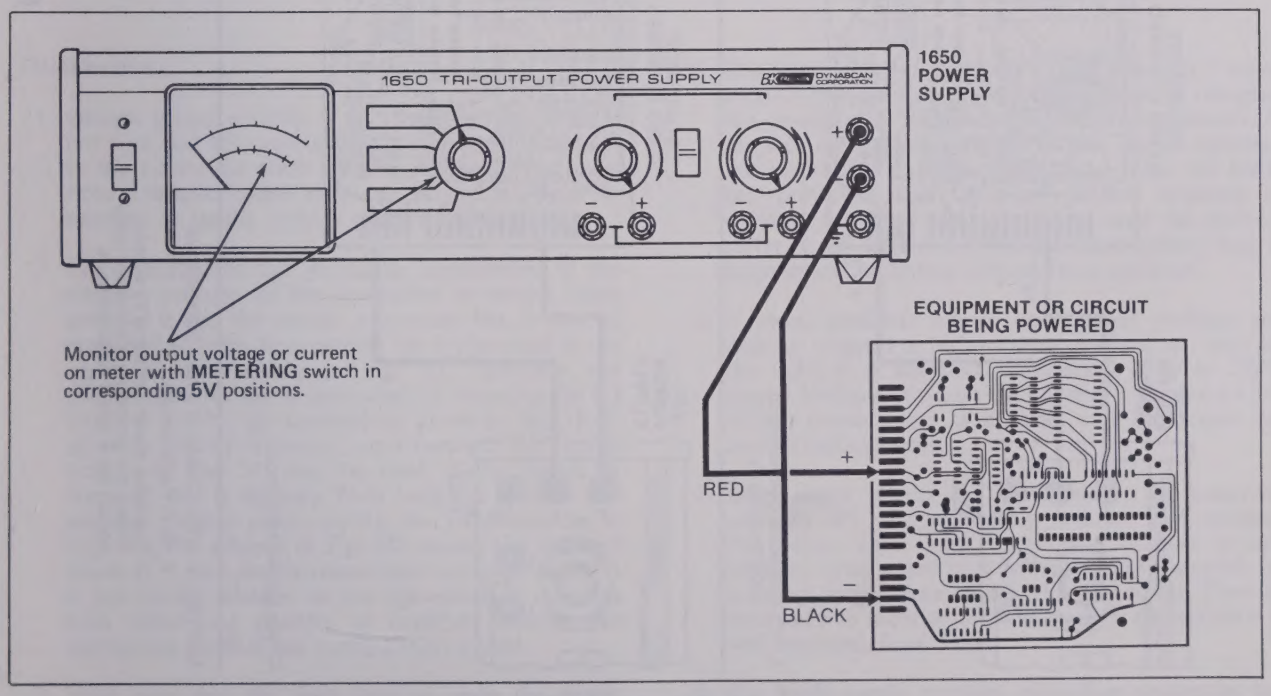
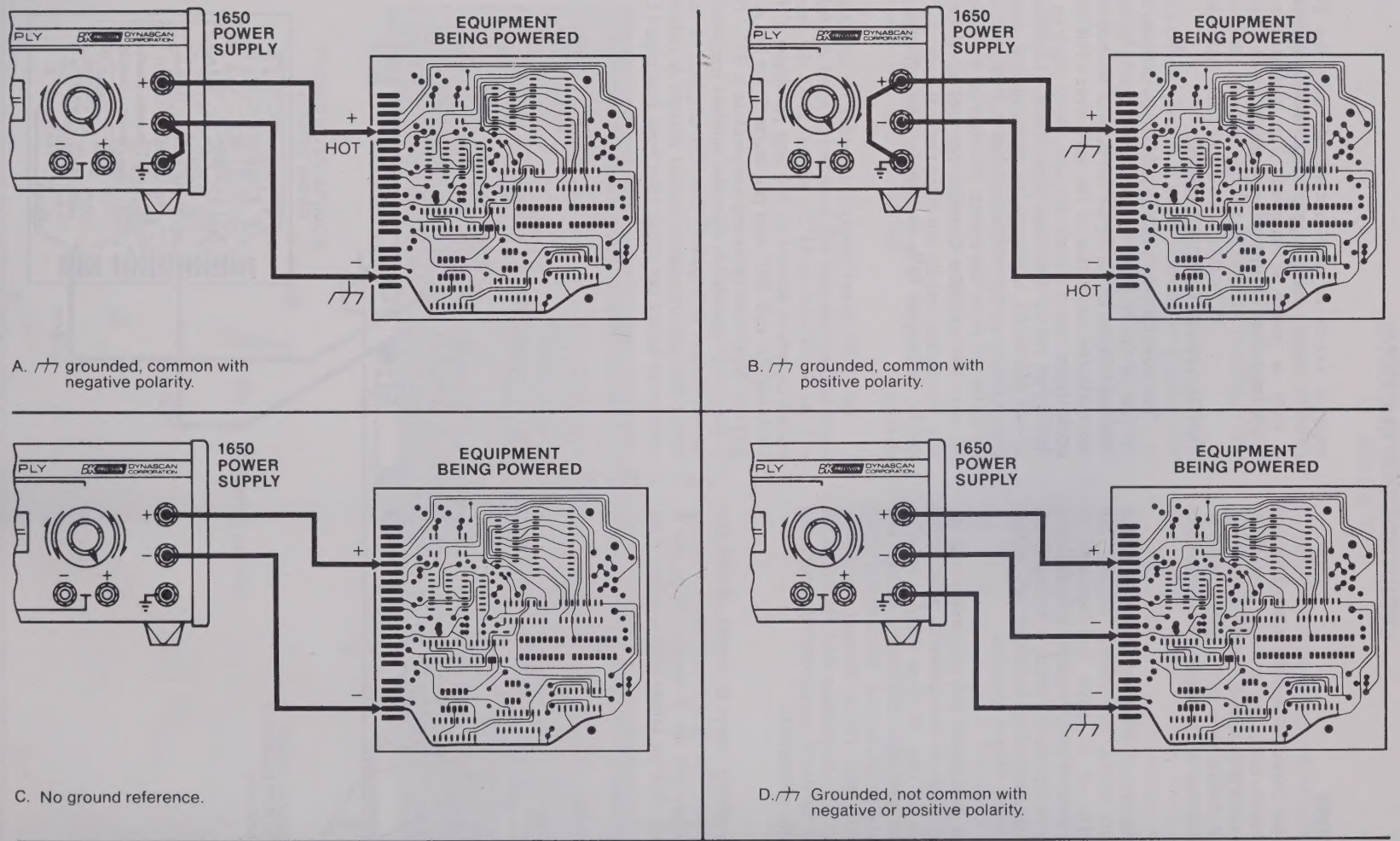


Fig. 2. Typical use of 5-volt supply.



NOTES: 1. ⏚ = Chassis or circuit common bus.
2. ⏚ = Earth ground.
3. Examples shown are using **5V** supply output, but grounding possibilities apply equally for **A** and **B** supply outputs.

Fig. 3. Grounding possibilities.

USE OF 5-VOLT SUPPLY

The 5-volt supply provides a fixed 5 volts DC output at up to 5 amps. This procedure covers the use of the 5-volt supply when it is the only power source of the tri-output unit in use.

Procedure

1. Turn off power supply while making connections.

2. Connect the positive and negative polarities of the equipment or circuit being powered to the red (+) and black (−) 5 VOLTS terminals of the power supply, respectively, as shown in Fig. 2.

3. Make ground connection, if required, as shown in Fig. 3.

4. Turn on power supply.

5. Measure output voltage and current of 5-volt supply on built-in meter. Place METERING switch in 5V positions. Use the 0-5V position and read voltage on the 0-5V scale; use the 0-5A position and read current on the 0-5A scale.

6. If the voltage is low and current is 2.5 to 5 amps, the supply is overloaded and current limiting is in effect.

7. If the voltage and current both read zero, the internal protective fuse is probably blown. This can be caused by prolonged overload near the threshold of foldback current limiting (6 to 7 amps). Disconnect the external equipment and replace the fuse (see "MAINTENANCE" section of this manual for fuse replacement information). Try to reduce the external load before reconnecting.

Considerations

1. Observe proper polarity. If the circuit being powered is not equipped with reverse polarity protection, damage to the circuit can result from reverse polarity connections. Use color-coded leads, one red and one black for example, to readily identify polarity of connections.

2. Fig. 3 illustrates the grounding possibilities. If the negative polarity of the equipment or circuit being powered is also the chassis or common bus, it may be grounded to earth by strapping the (−) terminal to the ⏚ terminal as shown in Fig. 3A. Similarly, the positive polarity can be grounded by strapping the (+) terminal to the ⏚ terminal as shown in Fig. 3B. If an earth ground reference is not required, the configuration in Fig. 3C may be used. If the chassis or common bus is separate from both the positive and negative polarity power inputs, use the connection in Fig. 3D. The scheme in Fig. 3D should also be used where +, −, and chassis connections are possible and it is not known whether or not the chassis is common with either the positive or negative polarity. No damage can result if this configuration is used.

3. Make sure that the leads used to make the power connections offer low voltage drop between the power supply and the circuits being powered. Use power leads of at least 18 gauge diameter, and make sure that connectors and points of contact offer low resistance. At 5 amps, even 0.1 ohm resistance in each power lead will drop the 5-volt output to 4 volts at the equipment being powered.

4. Overload current limiting begins at about 7 amps (less at high temperatures) and gives protection against excessive overload and short circuited output. The foldback characteristic shown in the graph in Fig. 4 takes effect before the protective fuse blows, dropping the output current in proportion to the degree of overload. If the output is short-circuited (maximum overload condition), the output voltage approaches zero and the current is limited at approximately 2.5 amps. Monitoring of the output voltage and current will detect any such overload condition. If the voltage is low, check the current. If the combination of voltage and current falls approximately within the "current limiting region" of the graph in Fig. 4, the power supply is overloaded.

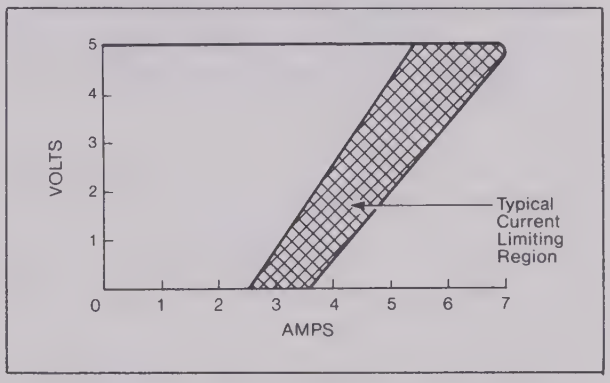


Fig. 4. Typical load regulation and foldback current limiting characteristic of 5-volt supply.

5. The 5-volt supply provides up to approximately 7 amps surge current at normal room temperature for charging the capacitors in the external circuit being powered. A surge of up to 7 amps will not initiate current limiting, but continuous current greater than 6 amps will blow the protective fuse. External current metering is required for this 5-to-6 amp range, since the built-in meter is full scale at 5 amps. Any load greater than 5 amps should be limited to short-term operation.

6. If more precision voltage and current readings are desired, connect a high-accurary multimeter, such as the 0.5% **B & K-PRECISION** Model 2810 or 2830 Digital Multimeter across the (+) and (−) terminals for voltage measurement or in series with the output for current measurement.

7. After initial set-up and connections, the meter is normally set to continuously monitor load current. The effect upon load current by variables in the circuitry being powered may be instantly evaluated, or a change may denote an abnormal condition. There is little need to monitor the voltage since the output is a well regulated, fixed 5 volts.

8. The 5-volt supply provides overvoltage protection for the circuit being powered in the rare case of a power

supply fault that would attempt to apply more than 7 volts output.

9. The power supply should not be connected into "hot" equipment so that an externally generated voltage is across the 5-volt terminals. However, the power supply contains overvoltage protection in the event that such voltage is accidentally applied. If the external voltage is not too stiffly regulated, the 5-volt regulator will attempt to bring it down to 5 volts. However, if regulation fails to bring the voltage down below 7 volts, the external voltage is short-circuited by a protective thyristor in the 1650. This should blow the fuse of the external power source for protection. If there is no fuse or protective device for the external power source, or it fails to open, the protective thyristor will be damaged by a prolonged short-circuit condition.

INDEPENDENT USE OF "A" SUPPLY

The A supply provides a variable 0-to-25 volts DC output at up to 0.5 amp. This procedure covers the use of the A supply when it is the only power source of the tri-output unit in use.

Procedure

1. Set the A VOLTS control to zero (fully counterclockwise).

2. Connect the positive and negative polarity of the circuit being powered to the (+) and (−) terminals of the A supply, respectively, as shown in Fig. 5.

3. Make earth ground connection, if required, the same as for the 5-volt supply (illustrated in Fig. 3). The only exception, of course is that strapping, if required, is between the ⏚ terminal and the + or − terminal of the A supply, rather than the + or − terminal of the 5-volt supply.

4. Place the METERING switch in the A positions. Use the 0-25V position and read the voltage from the 0-25V scale of the built-in meter.

5. Adjust the A VOLTS control to obtain the desired voltage.

6. If the desired voltage cannot be attained, current limiting is probably occurring from an overload. Place the METERING switch in the 0-.5A position and read output current from the 0-.5A scale of the built-in

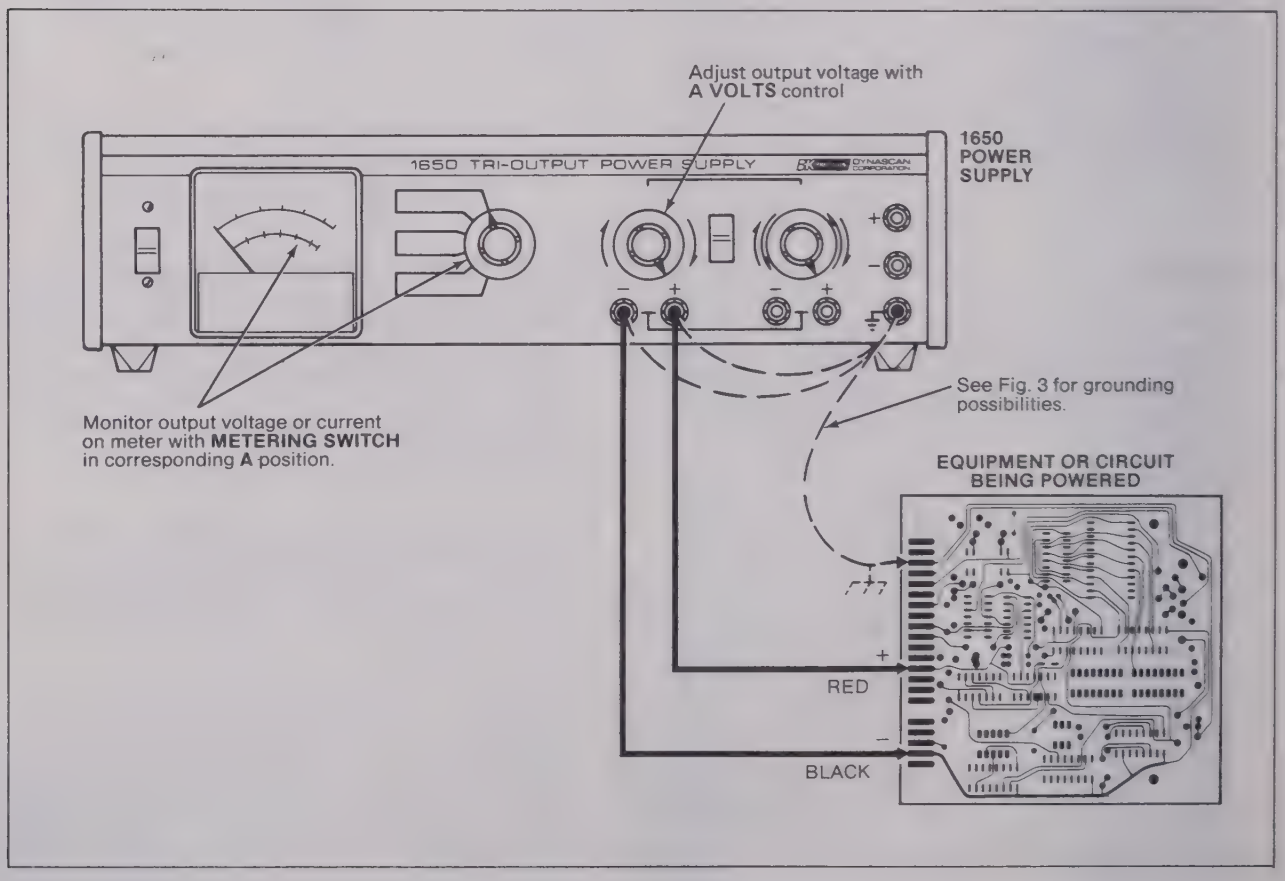

Adjust output voltage with A VOLTS control
1650 POWER SUPPLY
1650 TRI-OUTPUT POWER SUPPLY
Monitor output voltage or current on meter with METERING SWITCH in corresponding A position.
See Fig. 3 for grounding possibilities.
EQUIPMENT OR CIRCUIT BEING POWERED
RED
BLACK

Fig. 5. Typical use of A supply.

meter. Greater than full scale reading indicates an overload and current limiting.

7. After initial set-up and connections, place the METERING switch in the 0-.5A position and continuously monitor the load current on the built-in meter.

8. Voltage may be varied as desired by readjusting the A VOLTS control. Revert the meter to voltage monitoring to make such readjustments.

Considerations

1. Polarity of connections is just as important as described for the 5-volt supply.

2. Do not exceed the voltage rating of the circuit being powered. Many solid state devices will not withstand voltage of 25 volts.

3. For precision voltage or current readings, measure the output with a high accuracy multimeter.

4. Overload current limiting protects the A supply from overdissipation if the load is excessive. Overload current limiting begins somewhat above the rated current of 0.5 amp if the output is short-circuited, but may be significantly higher for mild overloads which do not cause excessive dissipation within the power supply. Overload conditions can be detected by observing the voltage and current readings of the meter. If the output is short circuited, the voltage will approximate 0 volts regardless of the setting of the A VOLTS control. Also, current will be limited at 0.5 amp or higher (unless the A VOLTS control is set fully counterclockwise). For overload conditions less severe than a short-circuited output, voltage readings will be normal near 0 volts. As the A VOLTS control setting is increased, voltage will reach a point where no further increase is possible. The greater the degree of overload, the lower the voltage at which this point occurs. This is the point where current reaches its limiting value and can be observed while monitoring the current meter. The overload protection characteristics are shown on the graph in Fig. 6.

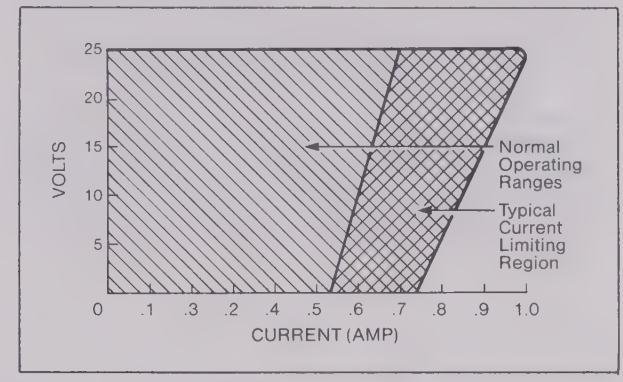


Fig. 6. Typical overload protection curve for A and B supplies.

GENERAL NOTES

1. The fixed 5-volt output can be readily readjusted with internal potentiometer R4. Typically, the output can be varied about ±1.5 volts. This makes the output usable in ECL logic applications which operate at −4.5 volts (100k ECL) or −5.2 volts (10k ECL). See Fig. 19 for the location of potentiometer R4.

2. Current derating at high temperatures is not an automatically compensated factor. If the power supply is operated at temperatures above 27° C (81° F), calculate the derating (page 7, last paragraph) and keep the load current below that value to prevent damage to the power supply. If the full rated output current is required, use intermittent duty operation, with 1 minute on maximum and several minutes off for cooling.

3. If the overvoltage thyristor in the 5-volt supply is gated into conduction, the power supply must be momentarily turned OFF to quench its conduction. Otherwise, the 5-volt output is shorted through the thyristor until it burns out.

INDEPENDENT USE OF "B" SUPPLY

The B supply also provides a variable 0-to-25 volt DC output at up to 0.5 amp and may be used instead of the A supply if desired as shown in Fig. 7. Procedures are very similar to those for using the A supply.

Procedure

1. Select INDEPENDENT mode.
2. Set the B VOLTS/TRACKING control to zero (fully counterclockwise).
3. Connect the positive and negative polarity of the circuit being powered to the (+) and (−) terminals of the B supply, respectively, as shown in Fig. 7.
4. Make ground connection, if required, the same as for the 5-volt supply and illustrated in Fig. 3. The only exception, of course, is that strapping, if required, is between the ⏚ terminal and the + or − terminal of the B supply, rather than the + or − terminal of the 5-volt supply.
5. Place the METERING switch in the B position. Use the 0-25V position and read the voltage from the 0-25V scale of the built-in meter.
6. Adjust the B VOLTS/TRACKING control to obtain the desired voltage.
7. If the desired voltage cannot be attained, current limiting is probably occurring from an overload. Place the METERING switch in the 0-.5A position and measure output current from the 0-.5A scale of the built-in meter. Greater than full scale reading indicates an overload and current limiting.
8. After initial set-up and connections, place the METERING switch in the 0-.5A position and continuously monitor the load current on the built-in meter.
9. Voltage may be varied as desired by readjusting the B VOLTS/TRACKING control. Revert the meter to voltage monitoring to make such readjustments.

Considerations

All considerations are identical to those of the A supply.

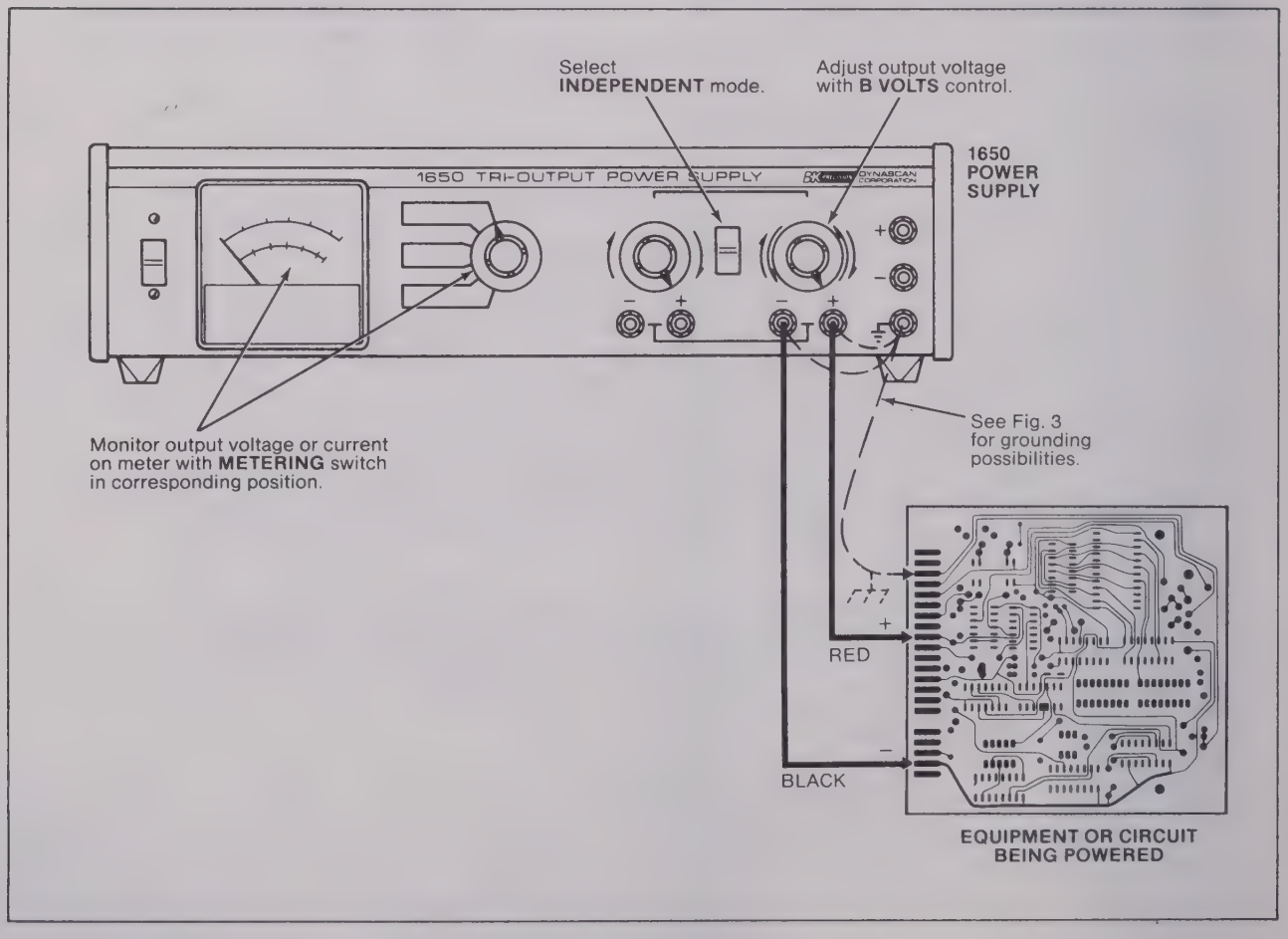


Fig. 7. Typical use of B supply.

TRI-OUTPUT (INDEPENDENT MODE)

All three supplies, or any two of the three, may be used simultaneously if desired. The supplies may be used to power two or three separate pieces of equipment or to power a circuit that requires two or three different voltage sources. In the INDEPENDENT mode, the A and B supply voltages are independently variable.

Operation is virtually the same as combining the operation for each individual supply as previously described. However, when providing multiple voltages to a single circuit such as shown in Fig. 8, a few additional factors should be considered.

1. Each supply's output is floating and independent of the other supplies. The chassis or common bus of the circuit being powered must be connected to each of the supplies in use. Only one common lead from the circuit being powered to the power supply is required, if strapping or jumpering is used between the common terminals of the other supplies (see Fig. 8 for an example).
2. Since more connections are required, and the possibility of making an incorrect connection increases, it is even more important to turn off the power supply while making connections. Additional power lead colors provide the handiest method of preventing incorrect connections.
3. If the 5-volt supply is overloaded and goes into current limiting, ripple voltage will increase sharply in the A and B supplies (the current limiting oscillation is coupled through the power transformer). Remove the 5-volt overload to keep the A and B supply ripple within specification.

TRACKING OPERATION

In the tracking mode, the output voltages of both the A and B supplies can be simultaneously varied with one control. The B supply voltage is preset to any desired ratio of the A supply voltage from 0-to-100%. Thereafter, adjustment of the A VOLTS control will vary both the A and B output voltages, while retaining the preset ratio between A and B. If the tracking ratio is set for 100%, the

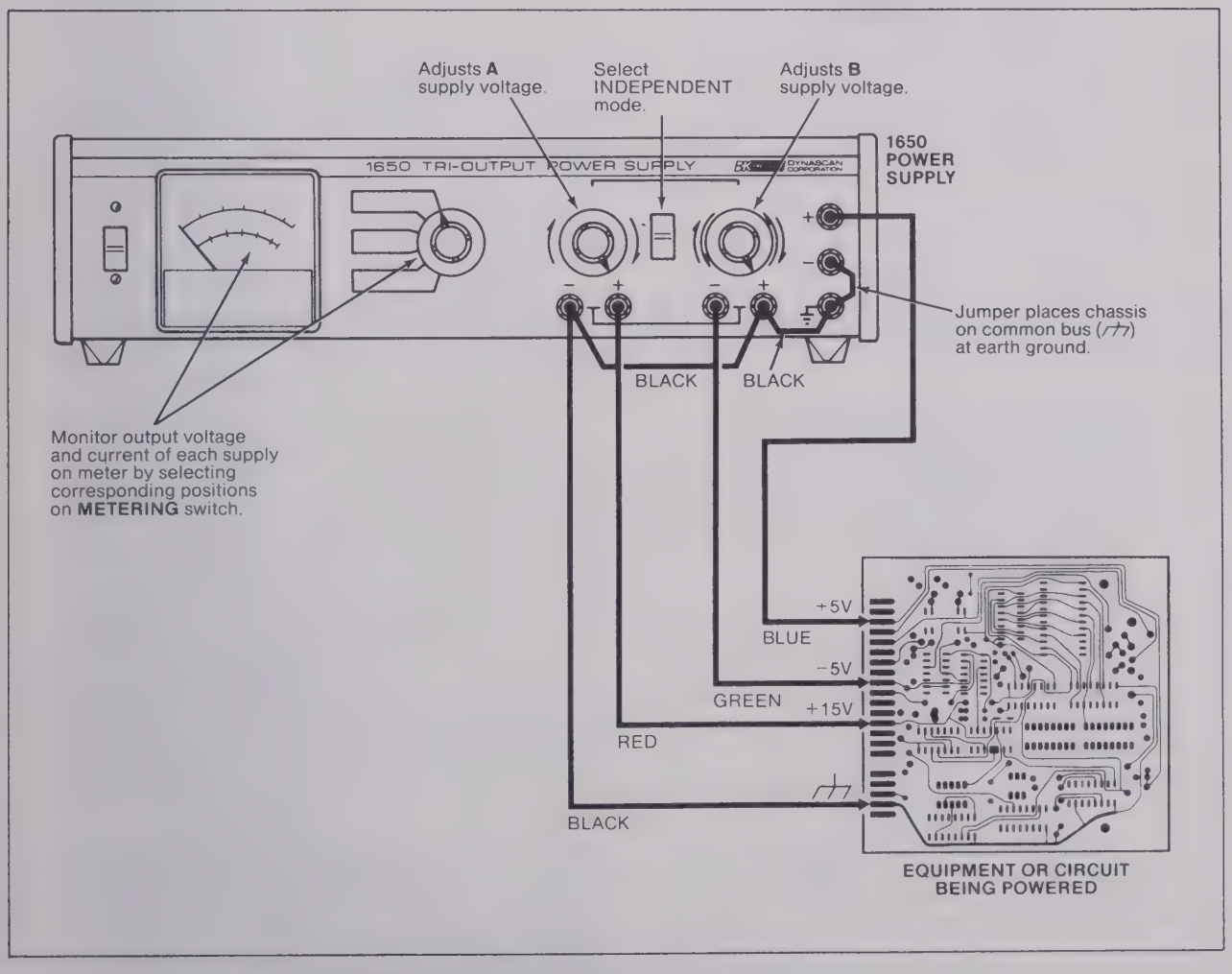


Fig. 8. Typical simultaneous use of three supplies.

A and B voltages will remain equal for any desired voltage setting (for highest tracking accuracy, stay within the 2-to-22 volts range). If the tracking ratio is set for 70%, the B voltage will track at 70% of whatever voltage is selected for the A supply. The A and B outputs may be connected in the same polarity (both positive or both negative), or back-to-back (one positive and one negative), or may be completely isolated, each with its own separate reference.

Procedure (Refer to Fig. 9)

The first steps should be performed before the power supply is connected to the circuit to be powered.

1. Select the B TRACKS A mode.
2. Select the A supply with the METERING switch. Use the 0-25V position and monitor the A supply voltage on the built-in meter.
3. Adjust the A supply voltage to the desired value with the A VOLTS control. If the tracking voltages are to be of unequal magnitude, *the A supply must be set to the higher of the two values.*
4. Select the B supply with the METERING switch. Use the 0-25V position and monitor the B supply voltage on the built-in meter.
5. Adjust the B supply voltage to the desired value with the B VOLTS/TRACKING control. Do not change this control setting after this step, except for a possible touch-up in Step 9.

   In the tracking mode, the B supply voltage is adjustable from 0-to-100% of the A supply voltage. Turn the B VOLTS/TRACKING control *counterclockwise* to increase the voltage; fully counterclockwise equals 100%. Although this direction of rotation may seem "backwards," it gives important over-voltage protection to the circuit being powered under most usual operating conditions. The reason is fully explained in the "Considerations" immediately after Step 10.
6. Turn off power supply while making connections, but leave controls as previously set.

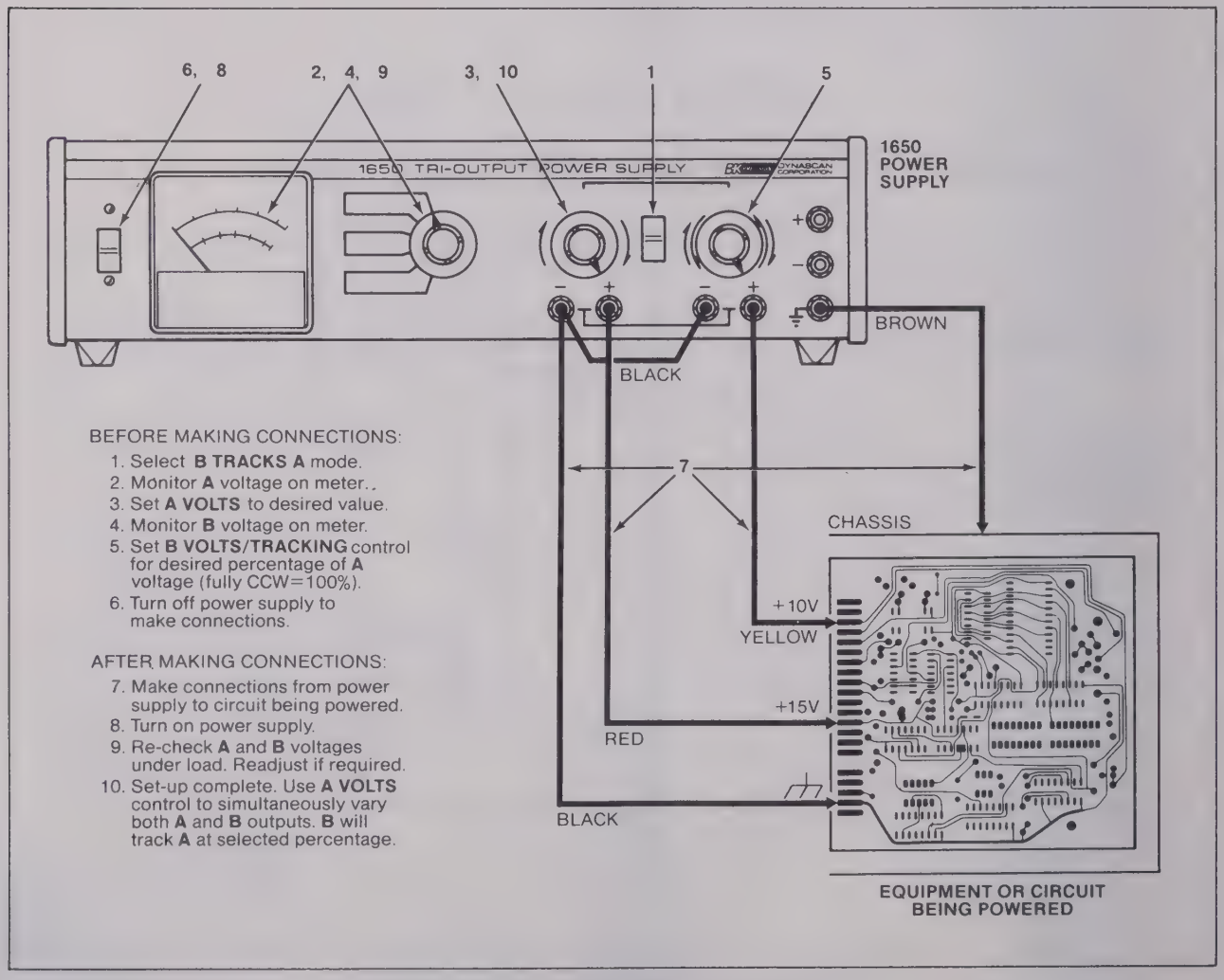

6, 8
2, 4, 9
3, 10
1
5
1650 TRI-OUTPUT POWER SUPPLY
1650 POWER SUPPLY
BROWN
BLACK
BEFORE MAKING CONNECTIONS:
1. Select B TRACKS A mode.
2. Monitor A voltage on meter.
3. Set A VOLTS to desired value.
4. Monitor B voltage on meter.
5. Set B VOLTS/TRACKING control for desired percentage of A voltage (fully CCW=100%).
6. Turn off power supply to make connections.
AFTER MAKING CONNECTIONS:
7. Make connections from power supply to circuit being powered.
8. Turn on power supply.
9. Re-check A and B voltages under load. Readjust if required.
10. Set-up complete. Use A VOLTS control to simultaneously vary both A and B outputs. B will track A at selected percentage.
7
CHASSIS
+10V
YELLOW
+15V
RED
BLACK
EQUIPMENT OR CIRCUIT BEING POWERED

Fig. 9. Set-up procedure for tracking mode.

7. Make connections between the supplies and the circuit being powered. Connections are the same as previously described for independent operation. Figs. 9, 10, and 11 show some typical examples.

These final steps would be performed after the connections have been made:

8. Turn on the power supply.

9. Recheck voltage and current of the A and B supplies under load. Make sure that current limiting is not occurring from an overload on either supply. If any touch-up of the voltage settings is desired, first adjust the A supply voltage, then the B supply voltage. Do not readjust the B VOLTS/TRACKING control after this step unless you intentionally want to change the ratio between the A and B voltages.

10. The unit is now ready for tracking operation. Monitor the A supply voltage on the meter and adjust throughout the desired voltage range. The B supply will track at the preset ratio and can be metered as required.

Considerations

1. Note that the direction of rotation required to increase the B supply voltage with the B VOLTS/TRACKING control is in the opposite direction in the B TRACKS A mode than in the INDEPENDENT mode. In the INDEPENDENT mode, 0 volts is fully counterclockwise, but in the B TRACKS A mode, 0 volts is fully clockwise (100% tracking is fully counterclockwise). This is a design feature that, under the majority of normal operating conditions, gives overvoltage protection to the circuit being powered in the event that the mode switch is accidentally or inadvertently operated. Most tracking operation will be performed at a tracking ratio of at least 50%, and the most common ratio will probably be 100%. At these higher tracking ratios, the control will be rotated well toward, or against, the counterclockwise limit. If the mode switch is inadvertently changed to the INDEPENDENT position, the B supply output voltage will go to a low voltage instead of a high voltage, the output will go to zero if the tracking was set for 100%. However, in certain conditions less often encountered, an overvoltage to the equipment being powered could result when switching modes. Always take care before making connections or changing modes to prevent such an occurrence.

2. For best tracking accuracy, both supplies should be operating in the 2-to-22 volt range. Tracking will operate over the entire 0-to-25 volt range, but at slightly less accuracy. Set-up should be performed at the higher end of the desired voltage range, rather than near zero volts.

3. For precision set-up, use a precision multimeter such as the **B & K-PRECISION** Model 2810 or 2830 Digital Multimeter in place of the built-in meter. For tracking ratios of 50% or higher, more accuracy can be achieved by measuring the difference between the A and B supply outputs than by measuring and adjusting the two voltages separately. Before connecting to the circuit to be powered, strap the negative terminals of the A and B supplies together. Measure the A supply output and accurately adjust the A VOLTS control for the desired voltage. Now connect the multimeter between the positive terminal of the A supply and the positive terminal of the B supply to measure the difference between the two voltages. Adjust the B VOLTS/TRACKING control for the desired difference between the two. For a tracking ratio of 100%, adjust for exact zero. Remove the strap and multimeter and connect the power supply to the equipment being powered in the desired polarity. This technique can be used regardless of whether the outputs are to be used with equal or opposite polarities. If this technique is used, do not attempt touch-up at Step 9 of the standard procedure.

4. Tracking operation implies that the voltages are to be varied over a certain range and the results evaluated. Therefore, the ratio between the A and B supply voltages may be more critical than the specific value of voltage during set-up. If so, the A supply may be set to a convenient reference such as 10 volts. The desired ratio is then easily converted into the desired voltage for the B supply.

5. The 5-volt supply may also be used while the A and B supplies are in the tracking mode. Operation of the 5-volt supply is totally independent of the A and B supplies and tracking operation will have no effect upon it. If the 5-volt supply is used, connect it at Step 7 of the procedure for tracking operation.

Applications

Tracking voltages are useful in evaluating the effects of voltage variation on circuits that are powered from two commonly derived voltages such as shown in Fig. 10. Tracking allows both voltages to be simultaneously varied the same percentage, which accurately simulates a fluctuation of the circuit's normal power source.

Back-to-back voltages at 100% tracking are useful in evaluating differential amplifiers, such as shown in Fig. 11. The same set-up would be used to evaluate the effects of voltage variation on circuits that are normally powered from equal + and − sources (+5 volts and −5 volts for example).

CONNECTING OUTPUTS IN SERIES

The outputs of the A and B supply may be connected in series to provide a variable 0-50 volt output at up to 0.5 amp. See Fig. 12 for the connection scheme. A 0-50 volt output can be obtained in either the independent or tracking mode.

The tracking mode is the handiest for most general purpose applications. Place the mode switch in the B TRACKS A position and set the B VOLTS/TRACKING control for 100% ratio. Now adjust the output voltage to the desired value with the A VOLTS control. Meter either the A or B supply voltage and double the value indicated to determine the total output voltage.

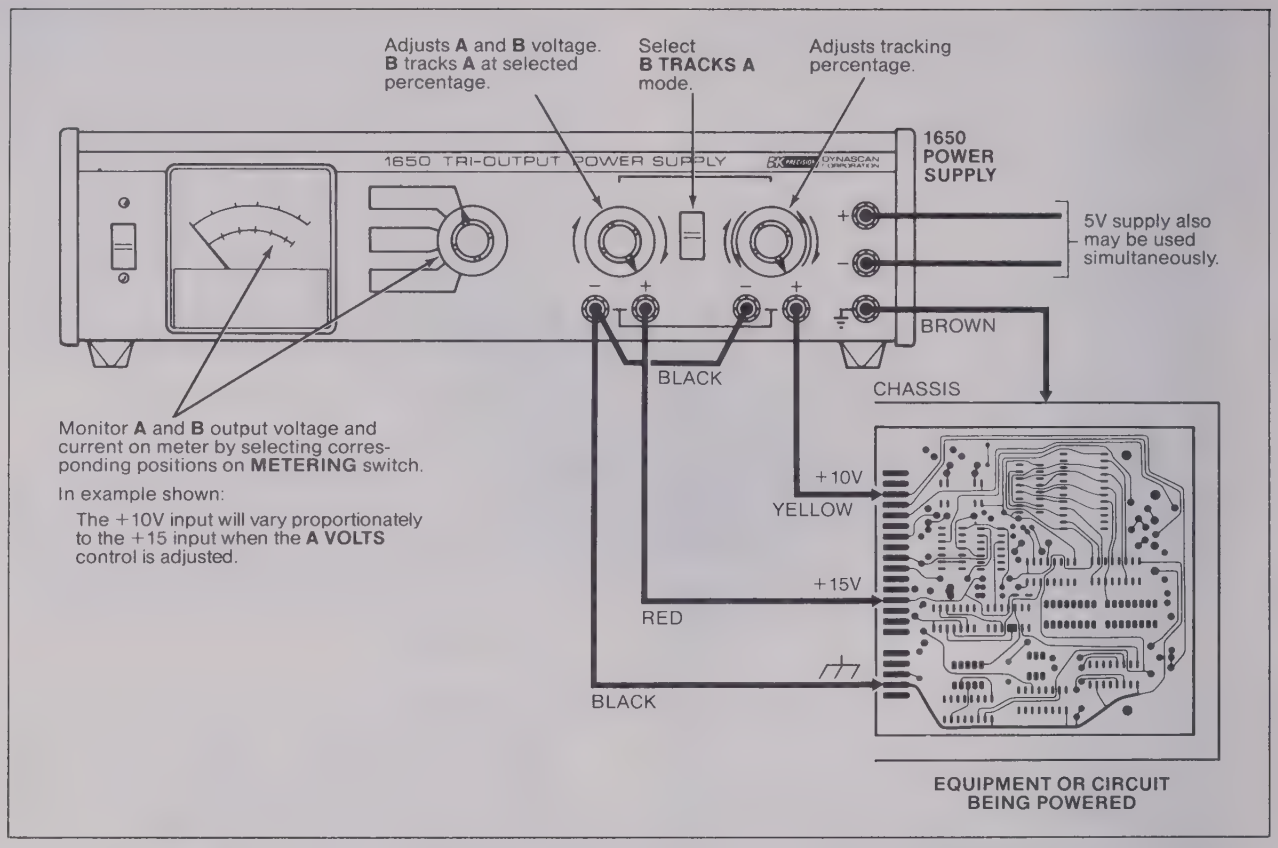

Adjusts A and B voltage. B tracks A at selected percentage.
Select B TRACKS A mode.
Adjusts tracking percentage.
1650 TRI-OUTPUT POWER SUPPLY
1650 POWER SUPPLY
5V supply also may be used simultaneously.
BROWN
BLACK
CHASSIS
Monitor A and B output voltage and current on meter by selecting corresponding positions on METERING switch.
In example shown:
The +10V input will vary proportionately to the +15 input when the A VOLTS control is adjusted.
+10V
YELLOW
+15V
RED
BLACK
EQUIPMENT OR CIRCUIT BEING POWERED

Fig. 10. Typical use of tracking mode for simulation of input voltage fluctuations.

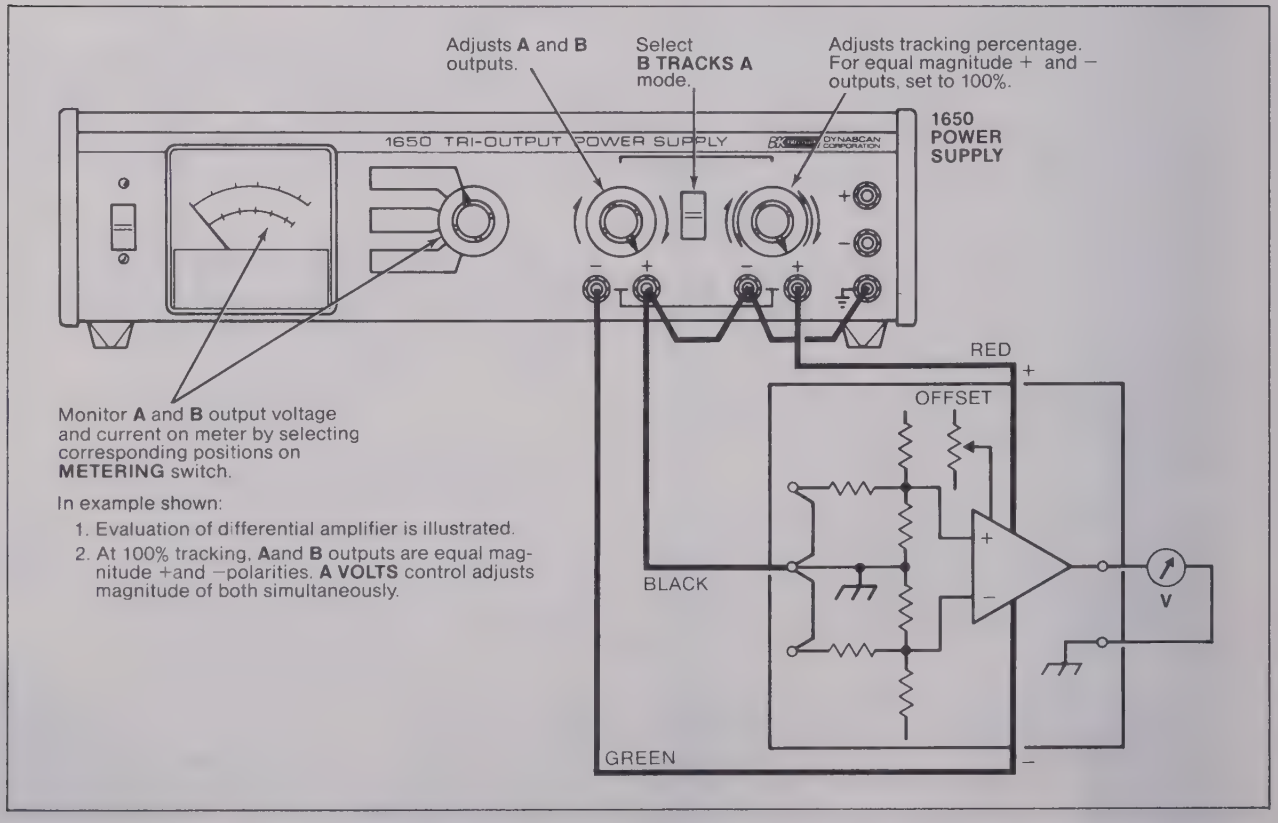

Adjusts A and B outputs.
Select B TRACKS A mode.
Adjusts tracking percentage. For equal magnitude + and − outputs, set to 100%.
1650 TRI-OUTPUT POWER SUPPLY
1650 POWER SUPPLY
RED
OFFSET
Monitor A and B output voltage and current on meter by selecting corresponding positions on METERING switch.
In example shown:
1. Evaluation of differential amplifier is illustrated.
2. At 100% tracking, Aand B outputs are equal magnitude +and −polarities. A VOLTS control adjusts magnitude of both simultaneously.
BLACK
V
GREEN

Fig. 11. Typical use of tracking mode for generating back-to-back voltages.

In the independent mode, the A VOLTS and B VOLTS/TRACKING controls each exercise control over a 0-25 volt range, giving finer control over the voltage adjustment. In this mode, the A supply and B supply output voltages must be metered separately and added together to determine the total output voltage, or an external meter may be connected across the load.

Load current may be monitored from either the A or B supply; the readings will be identical since they are connected in series.

A variable 5-55 volt output at up to 0.5 amp can be obtained by connecting the 5-volt supply in series with the A and B supplies. However, since a 0-50 volt output can be obtained with only the A and B supplies, there is no need for such a configuration unless the high end of the required voltage range falls between 50 and 55 volts. If such a configuration is used, the A and B supplies may be operated in the independent or tracking mode as previously described. The output voltages of all three supplies must be added to determine the total output voltage. An external voltmeter connected across the load is recommended. Output current can be measured from any of the three supplies, although better resolution can be obtained on the 0-.5A scale of the A or B supplies.

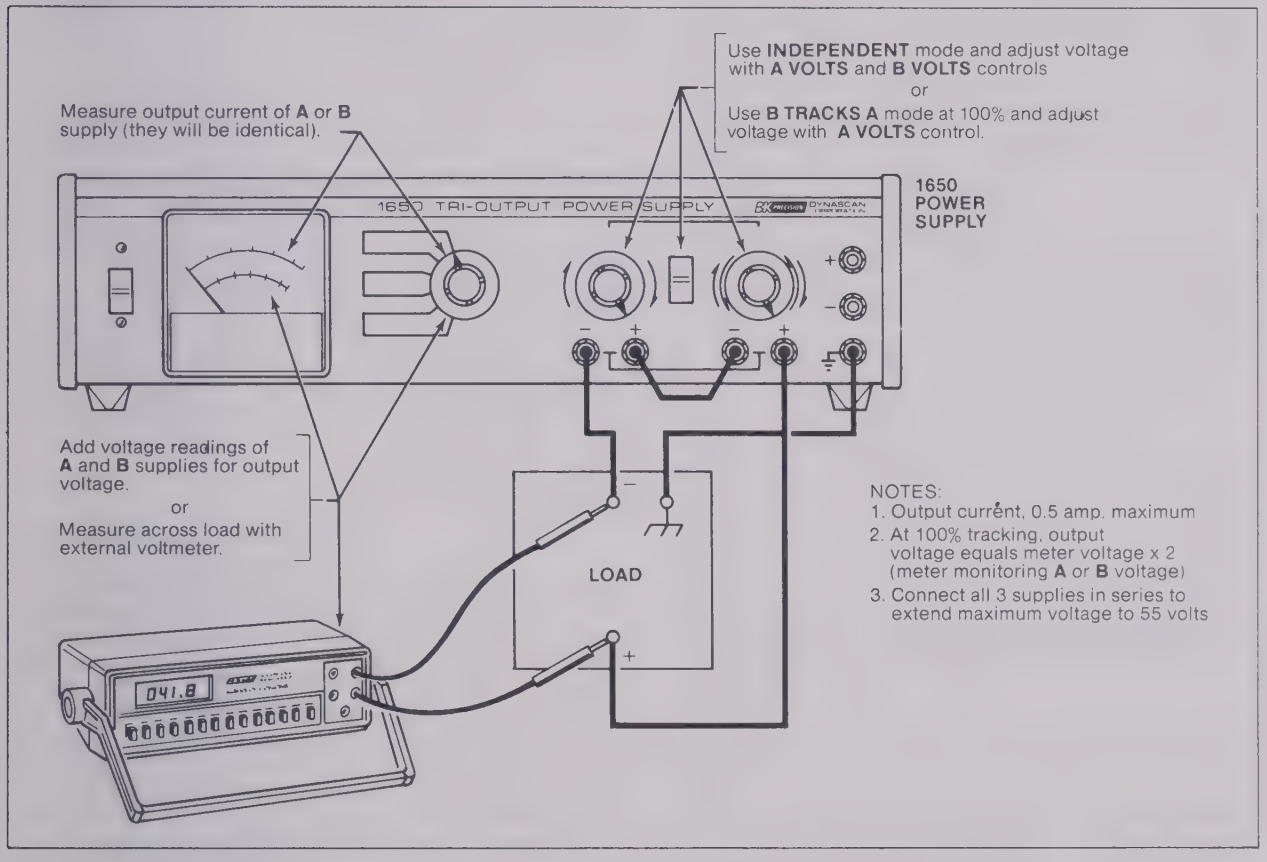

Use INDEPENDENT mode and adjust voltage with A VOLTS and B VOLTS controls
or
Use B TRACKS A mode at 100% and adjust voltage with A VOLTS control.
Measure output current of A or B supply (they will be identical).
1650 TRI-OUTPUT POWER SUPPLY
1650 POWER SUPPLY
Add voltage readings of A and B supplies for output voltage.
or
Measure across load with external voltmeter.
LOAD
NOTES:
1. Output current, 0.5 amp. maximum
2. At 100% tracking, output voltage equals meter voltage x 2 (meter monitoring A or B voltage)
3. Connect all 3 supplies in series to extend maximum voltage to 55 volts

Fig. 12. Connecting A and B supplies in series for 0-50 volt output.

NOTES

CONNECTING OUTPUTS IN PARALLEL

The A and B supplies may be connected in parallel to double the maximum load current. Such a configuration will provide a variable 0-25 volt output at up to 1 amp. Current equalizing resistors must be used as shown in Fig. 13. However, the protective current limiting feature will prevent damage if current is temporarily unbalanced during set-up.

The power supply may be operated in either the independent or tracking mode while operating with parallel outputs. The tracking mode at 100% tracking ratio is usually preferred because it is easier to maintain an approximate current balance when the voltage is changed. In either mode, use the A VOLTS control to adjust to the desired voltage and the B VOLTS/TRACKING control to obtain current balance. The output current of the A and B supplies should be equal. Except for the small differences between equalizing resistors, current balance can be obtained by measuring the differential voltage between the A and B supplies and adjusting for zero. If the current equalizing resistors are not well matched, it is preferable that the A and B voltages be slightly unbalanced to achieve current balance. If a precise voltage is desired, it should be measured across the load on an external multimeter. Total load current is the sum of A + B.

If a tracking ratio of greater than 100% is required to compensate for differences between the two current equalizing resistors, either swap the two equalizing resistors or use the independent mode.

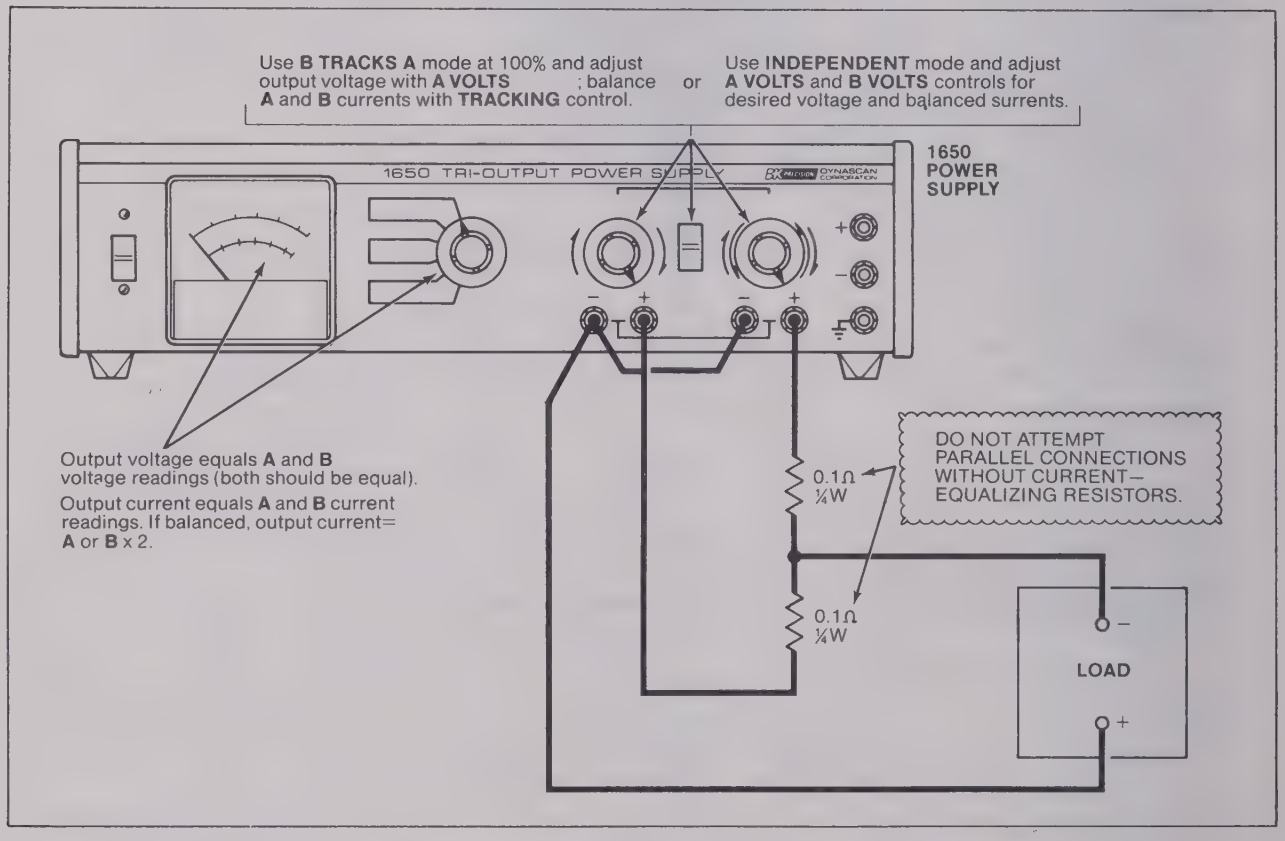

Use **B TRACKS A** mode at 100% and adjust output voltage with **A VOLTS** ; balance **A** and **B** currents with **TRACKING** control.
or
Use **INDEPENDENT** mode and adjust **A VOLTS** and **B VOLTS** controls for desired voltage and balanced currents.
1650 TRI-OUTPUT POWER SUPPLY
1650 POWER SUPPLY
Output voltage equals **A** and **B** voltage readings (both should be equal).
Output current equals **A** and **B** current readings. If balanced, output current= **A** or **B** x 2.
0.1Ω ¼W
0.1Ω ¼W
DO NOT ATTEMPT PARALLEL CONNECTIONS WITHOUT CURRENT– EQUALIZING RESISTORS.
LOAD

Fig. 13. Connecting A and B supplies in parallel for 0-25 volt, 0.5-1.0 amp output.

CIRCUIT DESCRIPTION

Refer to Fig. 14 for a block diagram analysis of the power -supply, and to the separately supplied schematic diagram for detailed circuit analysis.

5-VOLT SUPPLY

One of the secondary windings of power transformer T1 applies a low-voltage AC to two rectifier circuits in the 5-volt supply. Full-wave rectifier D1-D2 is the DC source for the 5-volt output; C1 is the filter capacitor. Rectifier D3-D4 is wired in a voltage doubler configuration and serves as the DC power source for 5-volt regulator IC1. The output voltage is regulated by controlling the conduction of series pass Darlington transistor Q1 through the action of 5-volt regulator IC1. A sample voltage on the wiper of R4, which is proportional to the output voltage, is applied to pin 4 of IC1. A 3.2-volt reference, derived from pin 6 of IC1, is applied to pin 5. IC1 compares the voltage of pin 4 to the reference voltage of pin 5. Any resulting error voltage is detected in IC1 and an output current from pin 9 is used to change the conduction of Q1 to restore equal voltages between pins 4 and 5 of IC1. Potentiometer R4 adjusts the output voltage level by changing the proportion of the output which is applied to pin 4 of IC1. This forces the output voltage to change until pin 4 again equals the 3.2-volt reference voltage at pin 5.

5-VOLT PROTECTIVE CIRCUITS

Foldback current limiting occurs if the load demands more current than the 5-volt supply can safely deliver. A current-limiting threshold is established by controlling the bias on pins 2 and 3 of IC1. Part of this bias is the voltage picked off from foldback divider D5, D6, and R8. Potentiometer R8 makes this pick-off point adjustable. The remainder of this bias is the voltage developed across current sensing resistor R90. With no load, no voltage is developed across R90 and the junction is reverse biased. As load current increases, the voltage developed across R90 also increases. The polarity of this voltage is opposite that picked off from the foldback divider. At the current-limiting threshold, the voltage across R90 is greater than that from the foldback divider and the junction is forward biased. Through the action of IC1, this limits the conduction of series pass transistor Q1 and prevents output current from increasing above this threshold value. If the load is further increased, the output voltage starts to drop below 5 volts and results in a foldback characteristic (current limits at a progressively lower value as terminal voltage decreases). This is because the pick-off voltage from the foldback divider decreases along with the output voltage, rebiasing the current-limiting threshold junction in a direction that reduces the limiting threshold.

Overvoltage protection for the circuit being powered is provided by the network containing zener diode D7, resistor R102, and thyristor TH1. In the rare case that Q1 shorts, the unregulated voltage across C1 will appear across the 5 VOLTS (+) and (-) terminals. At a maximum of 7 volts across D7 and R102, the voltage developed across R102 is sufficient to gate on thyristor TH1, which effectively shorts the (+) and (-) terminals and blows fuse F2 for protection.

This circuit (D7, R102, and TH1) also provides momentary overvoltage protection if an external voltage is applied to the 5 VOLTS terminals. The 5-volt regulator will first attempt to regulate the external voltage to 5 volts. However, if the voltage is too stiffly regulated and exceeds 7 volts, thyristor TH1 is gated on, which short circuits the external voltage source. This usually blows the fuse of the external supply and quickly removes the overvoltage for protection. Fuse F2 in the 1650 does not blow in this case, since it is not in the short-circuit current path. Since the thyristor network is a passive circuit, overvoltage protection continues when the 1650 is turned off. If there is no protective device to shut down the external supply, the continued heavy current will cause damage to TH1 from over-dissipation.

Network D7, R102, and TH1 also provide reverse polarity protection for the 5-volt supply circuits. If external voltage of reverse polarity (with sufficient energy to cause damage) is applied to the 5 VOLTS terminals, thyristor TH1 will be gated on and provide a virtual direct short. This circuit protects regardless of whether the 1650 is on or off. If the 1650 is turned on, and the impedance of the external voltage source is fairly high, the 5-volt supply may overpower the external source and regulate to 5 volts. The only noticeable result in such cases may be that the output current is higher than normal. If the impedance of the external voltage source is low, the 5-volt supply will oppose the external source up to the current-limiting point. If the external source still overpowers sufficiently to result in a reverse polarity across the (+) and (-) terminals, thyristor TH1 will be gated on and short the external voltage. Fuse F2 will not blow because the output of Q1 will not be excessive, and F2 is not in the current path of the external voltage source.

As with all reverse voltage protection devices, the design is meant to provide brief, non-continuous protection. In most cases, reverse polarity conduction of TH1 will blow the protective fuse in the external equipment and quickly remove the reverse polarity power. If reverse current through TH1 is prolonged, damage is probable because of over-dissipation.

A SUPPLY

The A supply uses a circuit configuration that is very similar to the 5-volt supply. The main differences between the supplies are:

1. Rectifier D11-D12 provides a higher DC voltage (approximately 32 volts) for the higher 0-25 volt output.

2. The voltage doubler is not used. The DC from rectifier D11-D12 is preregulated to 20 volts by Q2 and D8 to power IC2 (0-25V regulator) and IC4 (triangle wave oscillator and pulse width modulator).

3. Rectifier D13-D14 develops a low negative DC source that assures a minimum threshold conduction through Q3 when the A supply is set to zero.

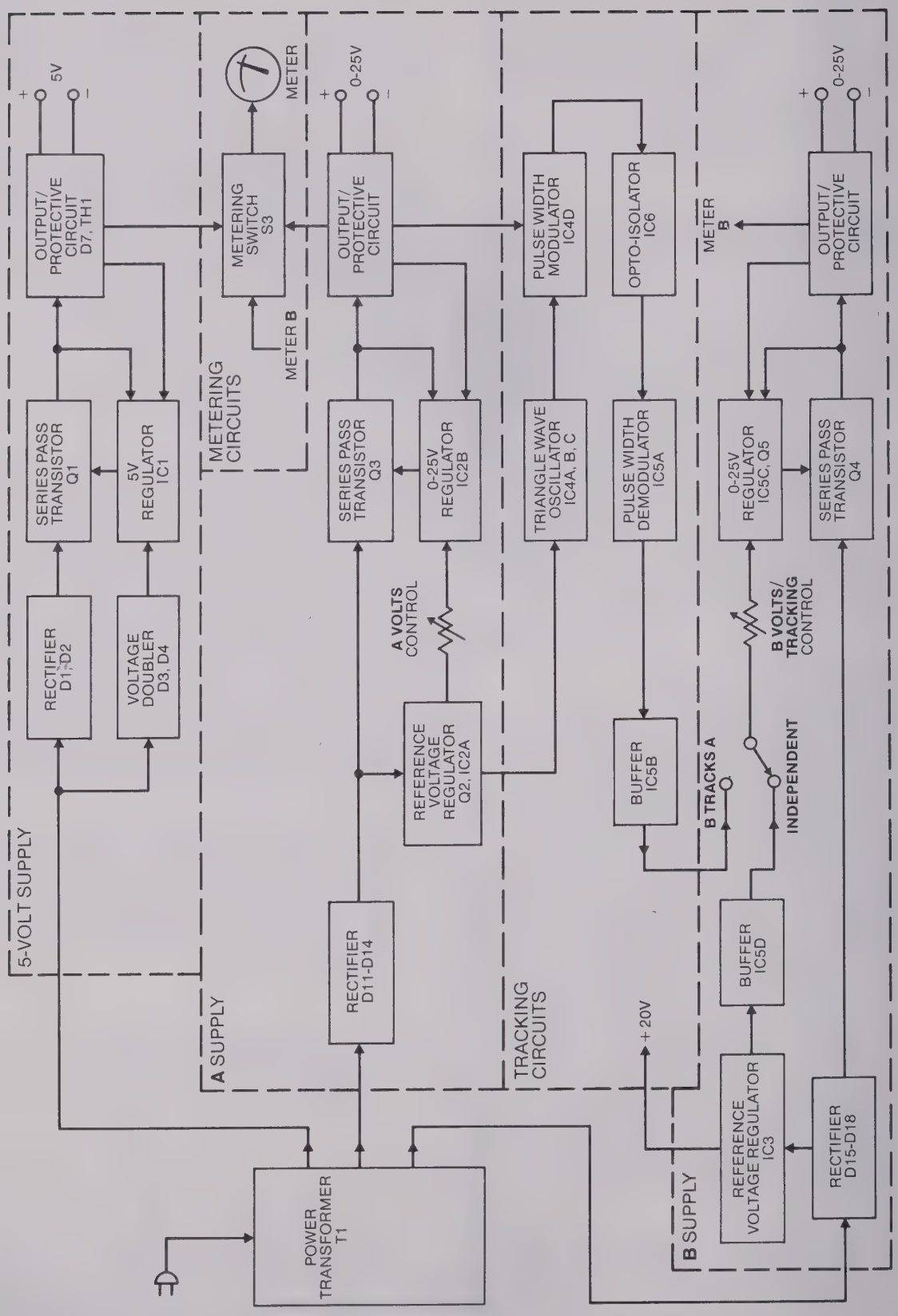


Fig. 14. Model 1650 Power Supply block diagram.

4. Potentiometer R14 provides an adjustable offset voltage to the differential amplifier to achieve equalization at zero output.

5. The foldback divider is fixed rather than adjustable.

6. The overvoltage protection circuit applies only to the 5-volt supply. However, zener diode D9 protects IC2 from overvoltage if Q3 should become shorted or if overvoltage is applied to the (+) and (-) terminals. All excess voltage is developed across R18.

B SUPPLY

The circuits used in the B supply during the independent mode of operation are very similar to those of the A supply. The primary differences between the B supply and the A supply are:

In the B supply:

1. All of IC3 is used as a pre-regulator to provide a highly regulated source of 20 volts to the 0-25 volt regulator and tracking circuits.

2. IC5D is used as a buffer for the B supply reference (from IC3 pin 6), which is used for both independent and tracking modes.

3. The B VOLTS control, R68, varies the reference voltage into the operational amplifier rather than varying the proportion of output voltage fed back to the operational amplifier. In the B supply, potentiometer R72 adjusts the proportion of output voltage fed back, thus establishing the gain of the 0-25 volt regulator.

TRACKING CIRCUITS

The tracking circuits allow the B supply voltage to track the A supply voltage at any ratio selected (0 to 100%) by the B VOLTS/TRACKING control, with complete isolation between the A and B supplies. The A supply output voltage is converted to a constant amplitude, variable pulse-width waveform (pulse-width modulation), coupled through an opto-isolator for complete electrical isolation, then average-filtered to become a DC level that controls the B supply output.

FUNCTION	5-VOLT SUPPLY	A SUPPLY	B SUPPLY *
Rectifier	D1-D2	D11-D12	D15-D16
Power source for regulator	D3-D4	Q2, D8	IC3
Series pass transistor	Q1	Q3	Q4
Regulator	IC1	IC2B	IC5C, Q5
Reference voltage source	IC1 (pin 6)	IC2A (pin 6)	IC3, IC5D
Differential amplifier	IC1 (pins 4, 5, and 13)	IC2B (pins 4, 5, and 13)	IC5C
Voltage adjust	R4 (internal)	R17 (A VOLTS control)	R68 (B VOLTS control)
Current-limiting threshold transistor	IC1 (pins 2, 3, and 13)	IC2B (pins 2, 3, and 13)	Q6
Current-sensing resistor	R90	R35	R81
Foldback divider	D5, D6, R4	R34, R95	R78, R79
Reverse polarity protection	D7, TH1	D10	D23
Current-metering resistor	R90	R92	R93

*Independent mode operation.

Table I. List of components which perform equivalent functions in each supply.

For a detailed analysis, refer to Fig. 15 and 16 along with the block diagram or schematic diagram. Pre-regulator Q2 provides a stable 20-volt source voltage for triangle wave oscillator and pulse width modulator IC4D, while IC2A provides a very stable reference voltage of approximately 7 volts to the triangle wave oscillator. Operational amplifiers IC4A, IC4B, and IC4C are connected in a triangle wave oscillator configuration that provides a very linear 14-volt (2 x 7V) peak-to-peak triangle wave. The frequency of oscillation is approximately 400 Hz, but the frequency is not critical.

IC4D is used as a voltage comparator functioning as a pulse width modulator. The triangle wave is applied to the negative input of operational amplifier IC4D. The A supply voltage is divided down and summed with a constant offset voltage from the 7-volt output of IC2A and applied to the positive input of IC4D as the threshold reference for the pulse width modulator. The offset voltage assures a minimum pulse width when the A VOLTS control is set to 2 volts. When the triangle wave is below the threshold reference, the output of IC4D is +19 volts. When the triangle wave is above the threshold reference, the output is zero. Thus the A supply voltage is always converted to pulses. The pulse width increases with increasing A supply output and decreases with decreasing A supply output (see Fig. 15). Therefore, the pulse width is directly proportional to the A supply voltage.

The pulses are applied to opto-isolator IC6, which uses a light coupling principle to couple the pulses to the averaging filter circuit IC5A, R56 and C22 (pulse width demodulator). This permits complete electrical isolation between the input and output. The input section of the opto-isolator uses an IRED (infrared emitting diode) to convert the pulses to light energy. The output section uses a light-sensitive photo diode driving an output transistor. When light energy is directed to the photo-diode junction, the output transistor conducts. Conduction ceases in the absence of light energy. Thus, the pulses are reconstructed in the output of the opto-isolator (across R58) with pulse-width information retained. The amplitude of the reconstructed pulse is not important as long as it exceeds the threshold level of IC5A. Neither is the waveshape too critical. As long as it is repeatable each time the A supply is returned to a given setting, tracking will be accurate. Adjustable offset voltage (R65) and gain (R66) can compensate for a wide variation of IC6 characteristics.

Operational amplifier IC5A is used as the pulse width demodulator. It amplifies pulses to a uniform amplitude and applies them to an averaging filter (R56 and C22) which develop a DC voltage that is proportional to pulse width. Buffer IC5B provides circuit isolation and matches tracking mode characteristics to independent mode characteristics. The DC level out of buffer IC5B becomes the reference voltage into the 0-25 volt regulator (operational amplifier IC5C) when the tracking mode is selected. B VOLTS/TRACKING control R68 selects the proportion of this reference voltage that is to be used, allowing ratios from 0 to 100% to be selected.

The tracking circuits operate continuously, regardless of the mode selected. However, the output of the tracking circuits is connected to the B VOLTS/TRACKING control only in the tracking mode. The reference voltage from the independent mode circuit is also disconnected when in the tracking mode. The connections to the B VOLTS/TRACKING control are reversed between the independent and tracking modes, which reverses the direction of rotation required to increase the output voltage.

Tracking offset adjustment R65 permits an offset voltage to be injected to match the B supply output voltage to the A supply output at low voltages. Adjustment is performed with tracking set at 100% and the A supply set at 2 volts. Tracking gain potentiometer R66 adjusts the tracking mode to match the independent mode gain and matches the B supply output voltage to the A supply output at 22 volts.

METERING

The METERING switch, S3, connects the built-in panel meter to measure the voltage or current of any of the three supplies. Precision resistors in series with the meter change the full-scale sensitivity from 5 volts when metering the 5-volt supply, to 25 volts when metering the A or B supply. The full-load current of each supply is drawn through a 1% precision current-metering resistor, developing a voltage across the resistor which is proportional to load current. The meter actually measures this voltage, which is converted back to the equivalent load current on the meter scale. R85 calibrates the meter when the A supply output is set to 25 volts. This setting of R85 also calibrates the meter for all other ranges.

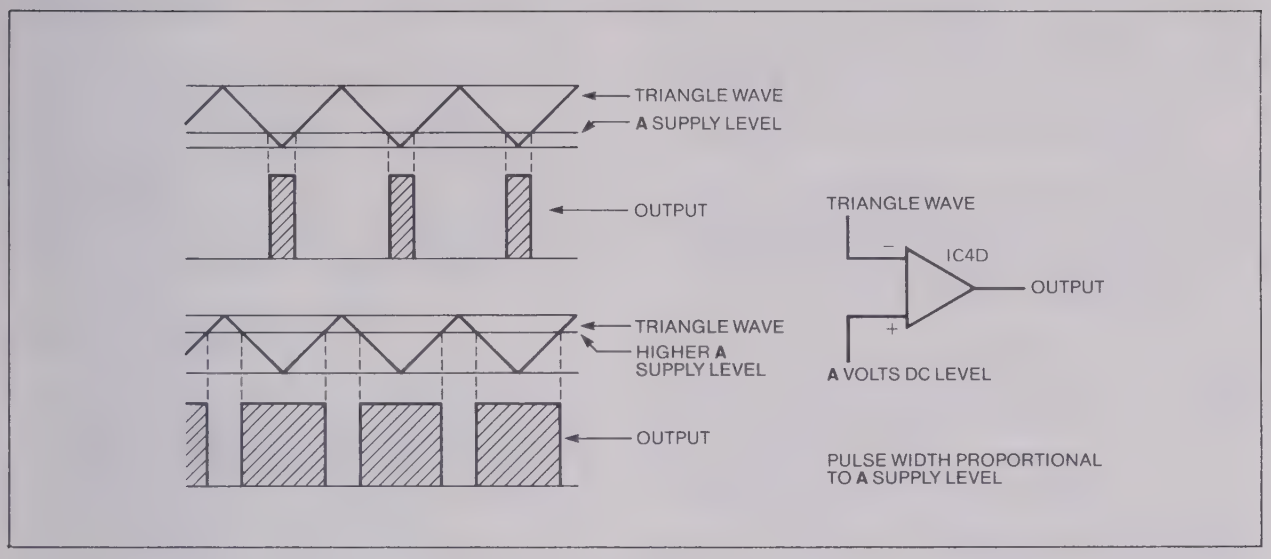


Fig. 15. Pulse width modulation.

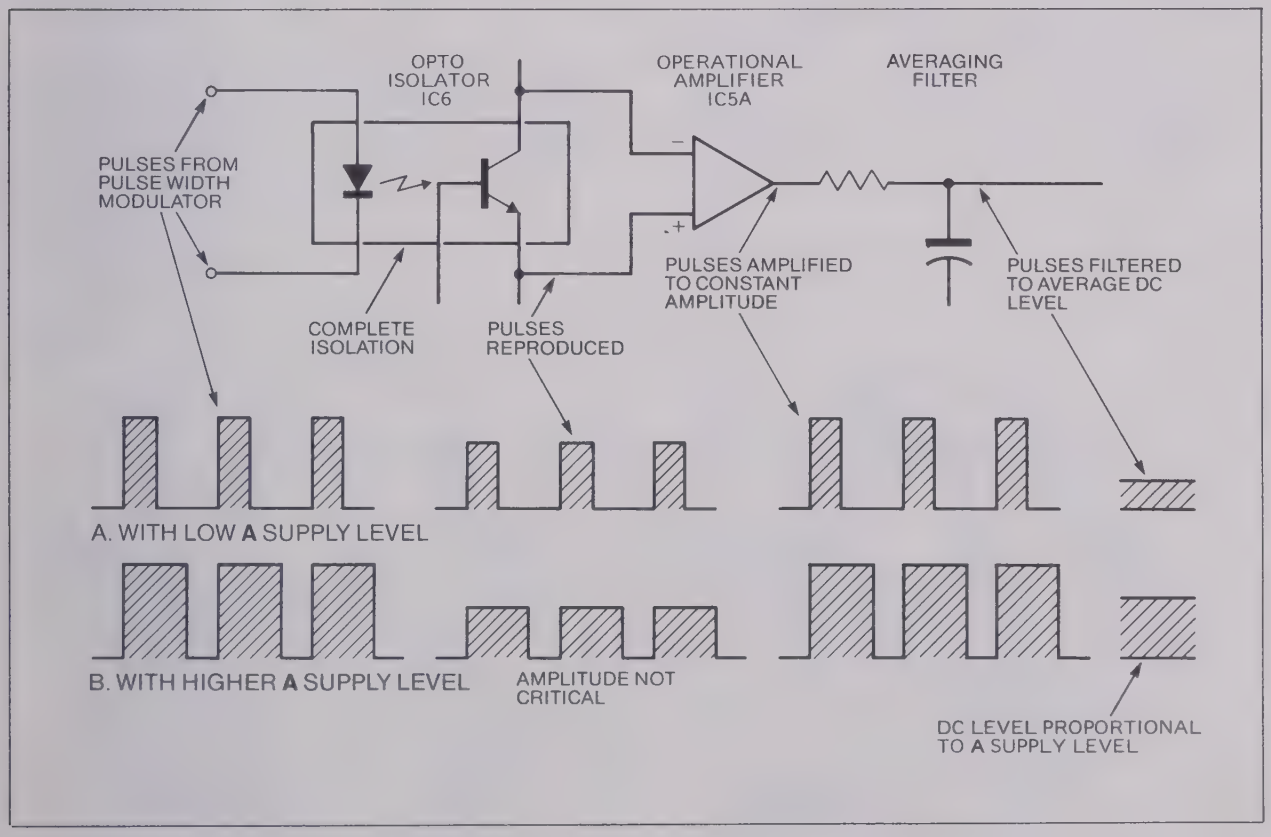

OPTO ISOLATOR IC6
OPERATIONAL AMPLIFIER IC5A
AVERAGING FILTER
PULSES FROM PULSE WIDTH MODULATOR
COMPLETE ISOLATION
PULSES REPRODUCED
PULSES AMPLIFIED TO CONSTANT AMPLITUDE
PULSES FILTERED TO AVERAGE DC LEVEL
A. WITH LOW A SUPPLY LEVEL
B. WITH HIGHER A SUPPLY LEVEL
AMPLITUDE NOT CRITICAL
DC LEVEL PROPORTIONAL TO A SUPPLY LEVEL

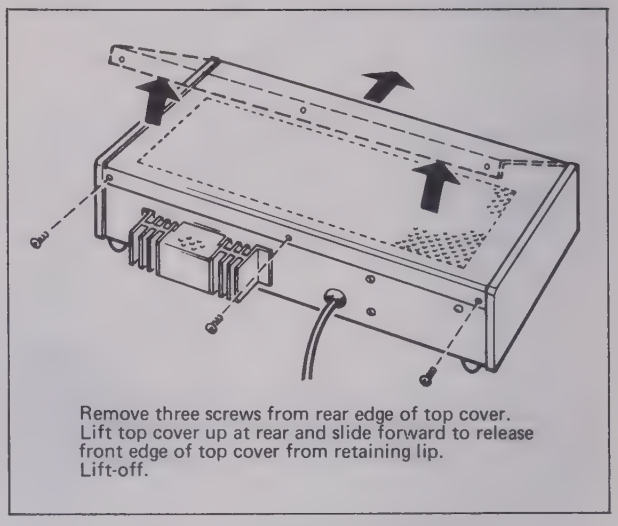
Fig. 16. Pulse width demodulation.

WARNING

1. The following instructions are for use by qualified personnel only. To avoid electric shock, do not perform servicing other than contained in the operating instructions unless you are qualified to do so.
2. **When the power is connected to an AC outlet, even if POWER switch is OFF, AC line voltage is present on the POWER switch, fuse F1, power transformer T1, and the adjoining terminal strip. Observe caution.**

REMOVAL OF TOP COVER

The top cover must be removed from the power supply for access to components and for performing all maintenance and calibration adjustment procedures. Refer to Fig. 17 and remove the top cover as shown in the illustration.



Remove three screws from rear edge of top cover. Lift top cover up at rear and slide forward to release front edge of top cover from retaining lip. Lift-off.

Fig. 17. Removal of top cover.

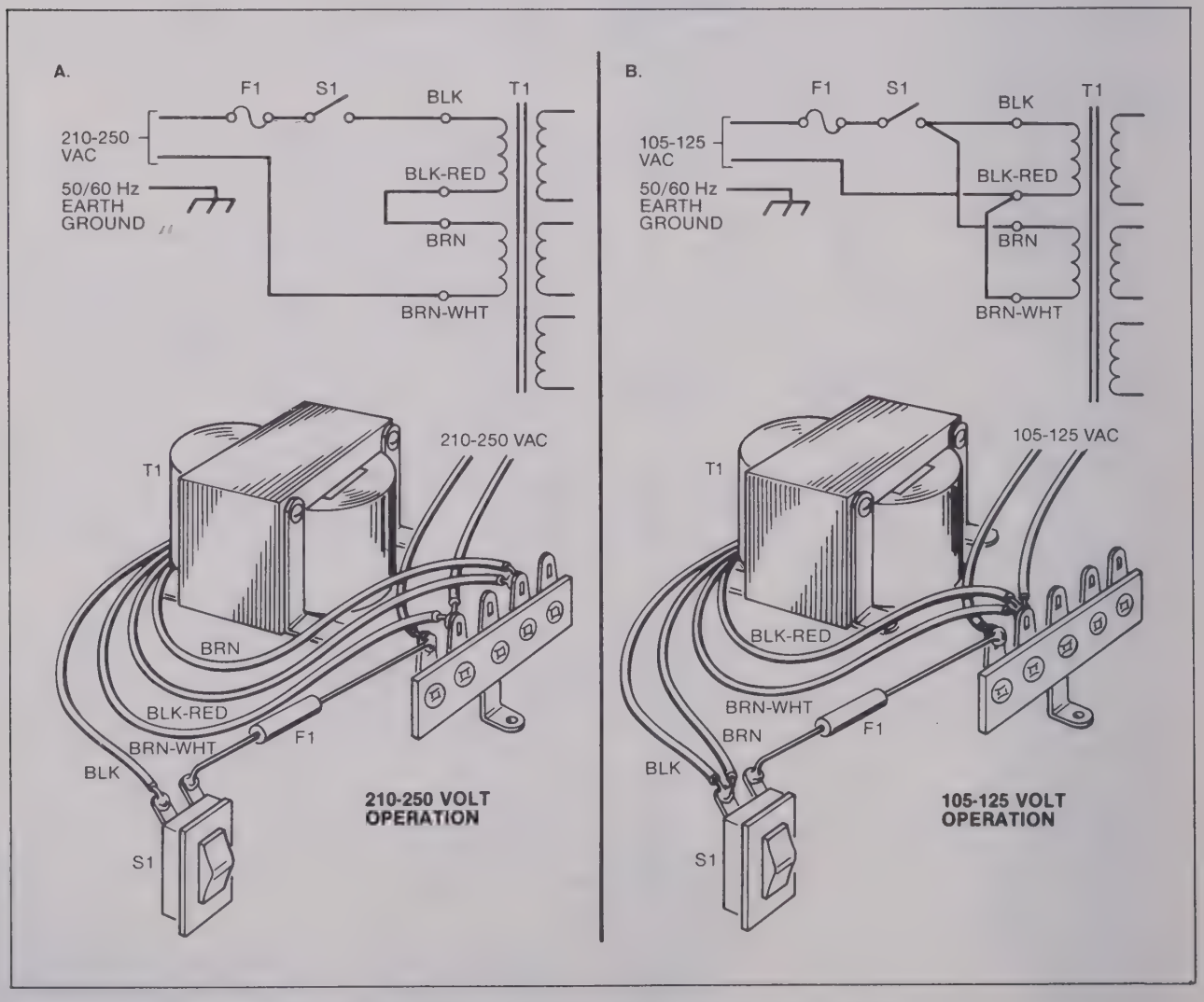


Fig. 18. 210-250 to 105-125 volt conversion (export models).

LINE VOLTAGE CONVERSION (EXPORT MODELS)

Export models are factory-wired for operation from 210-250 volt, 50/60 Hz AC power, but can be wired for 105-125 volt, 50/60 Hz AC operation. Fig. 18 shows both wiring schemes. To convert from 210-250 volt operation to 105-125 volt operation, move the brown primary lead of power transformer T1 from the terminal strip to switch S1 (same pin as black lead), and move the black-red lead to the same terminal as the brown-white lead. Also, change fuse F1 from 3/4A to 1½A value.

FUSE REPLACEMENT

Fuse F1 is in series with the primary of the power transformer. If fuse F1 blows, there will be no output from any of the three supplies and the meter illumination will go out. Automatic current limiting protects the power supply from overloading and this fuse should not normally open unless a problem has developed in the unit.

Fuse F2 is located in series with the 5 VOLTS output terminals. If F2 blows, there will be no 5-volt output, but the A and B supplies will operate normally. This fuse will blow if a continuous load of 6-7 amps is applied to the 5-volt supply.

Try to determine and correct the cause of the blown fuse, then replace only with a 1¼ amp, slow-blow type for F1 (for 50/60 Hz export model, use 3/4 amp fuse for 210-250 VAC operation or 1½ amp for 105-125 VAC operation), or a 6-amp, fast blow type for F2. Both fuses are the wired-in type, mounted inside the power supply. Refer to Fig. 19 for fuse locations.

BASIC TROUBLESHOOTING CHECK LIST

If there is no output from the 1650, be sure to make the following basic checks before assuming there is a defective component, etc:

1. Is unit plugged into a "live" AC outlet?
2. Is the unit turned ON?
3. Are fuses F1 and F2 OK? (See preceding "FUSE REPLACEMENT" paragraph.)
4. Is line cord OK?

If these steps do not correct the problem, return the unit for service as instructed in the "WARRANTY SERVICE INSTRUCTIONS."

CALIBRATION ADJUSTMENTS

This unit was carefully checked and calibrated at the factory prior to shipment. Readjustment is recommended *only* if repairs have been made in a circuit that affects calibration, or if you have reason to believe the unit may be out of calibration. Complete recalibration procedures are given in this manual. However, calibration adjustments should be attempted only if the proper test equipment is available, and you are experienced and qualified in its use.

See Fig. 19 for locations of all calibration adjustments. Perform calibration adjustments at room temperature and 120 VAC.

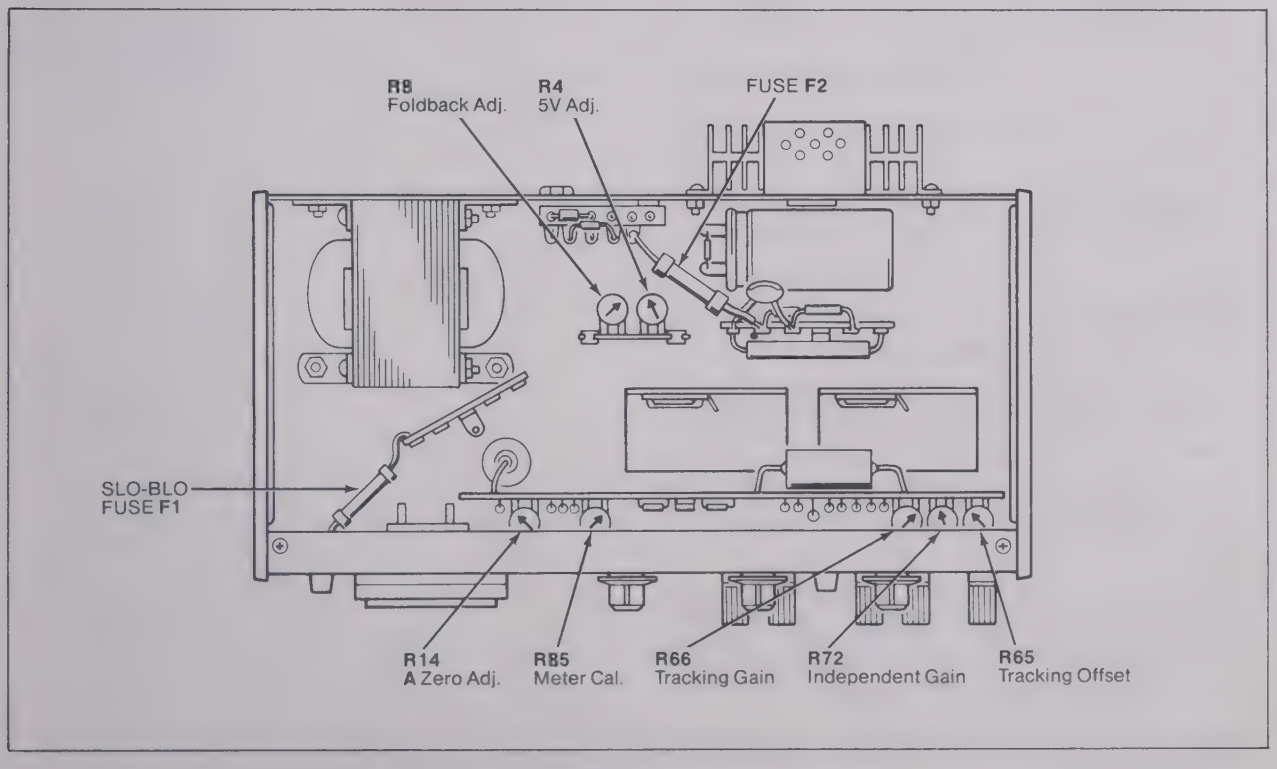


Fig. 19. Fuse and calibration adjustment locations.

Test Equipment Required

1. DC multimeter, 0.5% accuracy or better, **B & K-PRECISION** Model 2810 or 2830 or equivalent.

2. Power supply load. Must load 5-volt supply to 5 amps. A variable load such as an electronic load or power resistor decade box is preferred, but a 1-ohm fixed load of at least 50 watts rating may be used.

A Supply Adjustment

1. Connect the multimeter to measure the voltage at the A supply terminals with no load.

2. Turn the A VOLTS control fully counterclockwise against the stop.

3. Adjust R14 (A zero adj.) for 0.0 volts (less than 25 mV) on the multimeter.

Metering Adjustment

1. Connect the multimeter to measure the voltage at the A supply terminals.

2. Set the A VOLTS control for 25.0 volts on the multimeter.

3. Set the METERING switch to the A, 0-25V position.

4. Adjust R85 (meter cal) for 25.0 volts on the built-in meter.

B Supply Adjustment

1. Connect the multimeter to measure the voltage at the B supply terminals with no load.

2. Set the mode switch to the INDEPENDENT mode.

3. Set the B VOLTS/TRACKING control fully clockwise against the stop.

4. Adjust R72 (independent gain) for 25.3 volts on the multimeter.

Tracking Adjustments

1. First, perform the B supply adjustment.

2. Set the mode switch to the B TRACKS A mode and the B VOLTS/TRACKING control fully counterclockwise against the stop (100%).

3. Connect the multimeter to measure the voltage at the A supply terminals. Set the A VOLTS control for 2.0 volts on the multimeter.

4. Connect the multimeter to measure the voltage difference between the A and B supplies. Jumper together the negative polarities of the A and B supplies. Connect the + meter lead to the A supply + terminal and the - meter lead to the B supply + terminal.

5. Adjust R65 (tracking offset) for +85 to +130 millivolts on the multimeter.

6. Again connect the multimeter to measure the voltage at the A supply terminals. Set the A VOLTS control for 22.0 volts on the multimeter.

7. Reconnect the multimeter to measure the voltage difference between the A and B supplies as in Step 4.

8. Adjust R66 (tracking gain) for +130 to +175 millivolts on the multimeter.

9. Repeat Steps 3 through 8 to eliminate any interaction.

5-Volt Supply Adjustments

1. First, set R8 (foldback adj.) fully counterclockwise. **CAUTION**: This step temporarily disables the foldback current-limiting action, and fuse F2 will blow if the load current reaches 6 amps.

2. Connect the multimeter to measure the voltage at the 5 VOLTS terminals.

3. Adjust R4 (5V adj.) for 5.00 to 5.02 volts.

4. Connect the multimeter and load in series across the 5-VOLTS supply output terminals. Set the multimeter to measure load current.

5. Adjust the load for 5 amps current on the multimeter.

6. Leave the load connected to the 5-volt supply, but reconnect the multimeter to measure the voltage at the 5 VOLTS terminals. Voltage should read 4.85 to 5.02 volts.

7. Turn R8 (foldback adj.) clockwise until the voltage reading on the multimeter drops to 4.0 to 4.5 volts, then reverse rotation and turn slowly counterclockwise until the meter reading *just* returns to reading in Step 6.

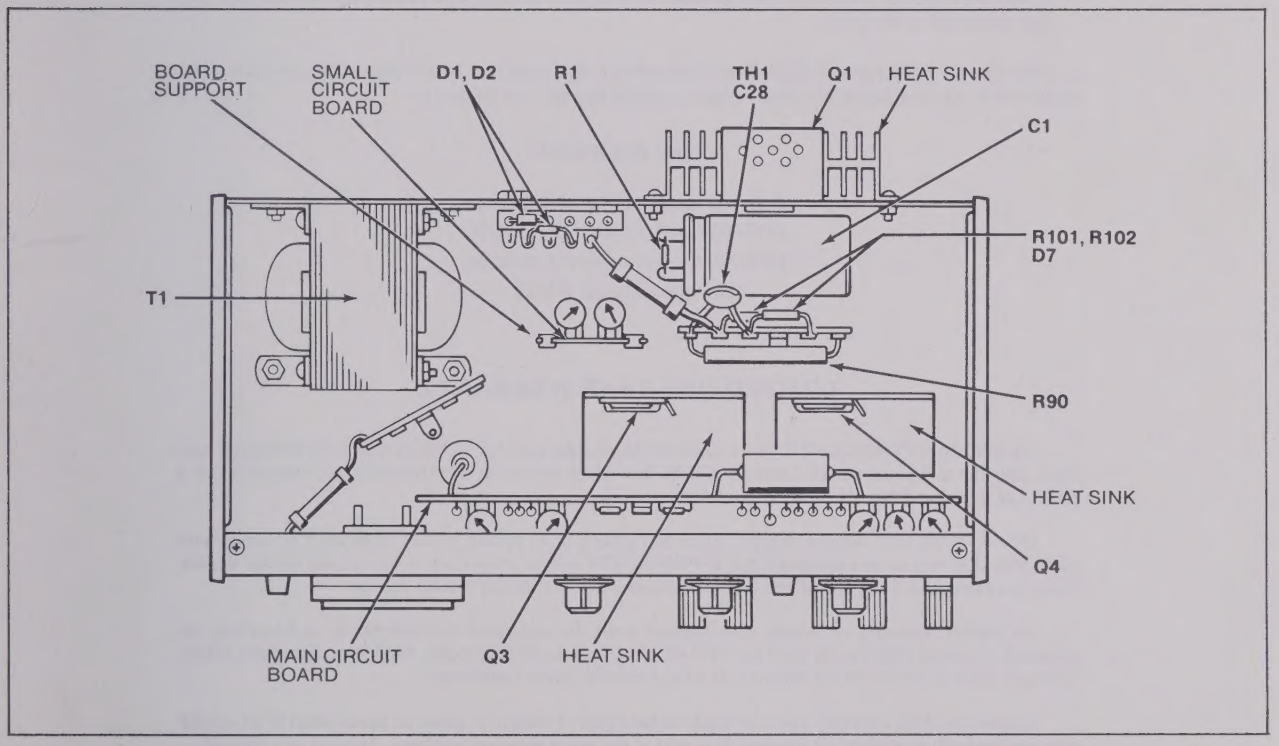


Fig. 20. Parts location of chassis-mounted parts.

WARRANTY SERVICE INSTRUCTIONS

1. Refer to the MAINTENANCE section of your B & K-Precision instruction manual for adjustments that may be applicable.

2. If the above-mentioned procedures do not correct the problem you are experiencing with your unit, pack it securely (preferably in the original carton or double-packed). Enclose a letter describing the problem and include your name and address. Deliver to, or ship PREPAID (UPS preferred) to the nearest B & K-Precision authorized service agency (see list enclosed with unit).

If your list of authorized B & K-Precision service agencies has been misplaced, contact your distributor for the name of your nearest service agency, or write to:

Service Department

B & K-Precision Product Group
DYNASCAN CORPORATION
4050 North Ravenswood Avenue
Chicago, Illinois 60613

LIMITED ONE-YEAR WARRANTY

DYNASCAN CORPORATION warrants to the original purchaser that its B & K-PRECISION product, and the component parts thereof, will be free from defects in workmanship and materials for a period of one year from the date of purchase.

DYNASCAN will, without charge, repair or replace, at its option, defective product or component parts upon delivery to an authorized B & K-PRECISION service contractor or the factory service department, accompanied by proof of the date of purchase in the form of a sales receipt.

To obtain warranty coverage, this product must be registered by completing and mailing the enclosed warranty registration card to DYNASCAN, B & K-PRECISION, 6460 West Cortland Street, Chicago, Illinois 60635 within fifteen (15) days from the date of purchase.

Exclusions: This warranty does not apply in the event of misuse or abuse of the product or as a result of unauthorized alterations or repairs. It is void if the serial number is altered, defaced or removed.

DYNASCAN shall not be liable for any consequential damages, including without limitation damages resulting from loss of use. Some states do not allow limitation of incidental consequential damages, so the above limitation or exclusion may not apply to you.

This warranty gives you specific rights and you may also have other rights which vary from state to state.

For your convenience we suggest you contact your B & K-PRECISION distributor, who may be authorized to make repairs or can refer you to the nearest service contractor. If warranty service cannot be obtained locally, please send the unit to B & K-PRECISION Service Department, 4050 North Ravenswood Avenue, Chicago, Illinois 60613, properly packaged to avoid damage in shipment.

B+K PRECISION DYNASCAN CORPORATION

480-251-9-001D

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